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OXIDE FILM BETWEEN FIRED GROUND-COAT ENAMELS AND IRON*

By Karl Kautz

Abstract

A study of the oxide film between enamel and iron was made by sticking together specimens of fired ground coat in a furnace and tearing them apart when cold so that the oxide film was separated from one of the iron surfaces. The chemical behavior of this film indicates that FeO is present. Microscopic examinations reveal a typical iron-scale structure. Chemical and X-ray analyses show that the film is composed principally of Fe, FeO, and Fe_3O_4.

I. Introduction

The writer mentioned in a previous paper[1] that a very thin film of ferrous oxide, or scale, existed between fired ground coats and iron and suggested that this probably was a contributing cause of adherence. This iron-oxide film, however, had been observed by microscopic methods only, and its existence has been questioned.[2] This paper deals with a further study and identification of this oxide film.

II. Preparation of Specimens

Specimens were prepared in the usual manner and were fired to the desired point. These specimens, in packs of four, were reheated in a furnace at 1600°F until the enamel became tacky, usually in about 3 minutes. The pack was pressed together in the furnace with heavy tongs, then withdrawn, and again pressed together at numerous places until it was cooled below a red heat. When completely cold, the specimens were torn apart, exposing the oxide film attached to one of the enamel layers.

Although this method is often unproductive of results because the enamel layers separate from each other instead of from the iron surface, frequently one or more of the four samples will show patches of the oxide film adhering to the enamel, and these samples are used for study.

III. Visual Examination

Numerous specimens showing the oxide film were prepared and visually examined. Figure 1 is a photograph (natural size) showing a typical film adhering to the enamel layer; Fig. 2 shows the iron surface from which this oxide film was separated.

The film to the unaided eye seems to be iron scale. It is dark gray and its surface texture appears to be identical with that of iron scale. The iron surface from which it was separated seems to be bright, metallically clean iron.

Samples of this exposed oxide film were prepared from ground-coat enameled-iron samples which were fired 2, 6, 20, and 60 minutes. Two minutes of firing permitted the milled ground coat to become molten or glossy. These samples showed an almost black, heavy oxide film. The normally fired samples (6 minutes) showed a lighter film of oxide (see Fig. 1) than the 2-minute series, judging solely by surface characteristics and its dark gray color. The overfired samples (20 minutes) showed to the unaided eye about the same color and thickness of oxide film as the normally fired samples. At 60 minutes, the ground coat, which was completely saturated with iron oxides, did not stick together firmly under this treatment, and when separated, it revealed little or none of the film adjacent to the iron. It seems that the oxide film at this stage of firing is so deeply imbedded and dissolved in the iron base that it no longer separates as a distinct layer. The parting seems to occur in the black glass layer immediately above the dissolved oxide film.

IV. Chemical Behavior

Samples of this oxide film from normally fired specimens, treated for 5 minutes with alcoholic stannous chloride (a reagent used to etch FeO in microscopic specimens), showed a definite etching. This indicates that FeO (ferrous phase) is present in the oxide film because the reagent attacks FeO rapidly and has but slight action on ground-coat enamel, iron, or Fe_3O_4.

Samples of this oxide film from normally fired specimens, heated in pure hydrogen at 1000°F (below the softening point of the ground-coat enamel), were reduced completely to metal. Qualitative chemical tests on this reduced metallic film show it to be metallic iron. If the reduced metallic film is exposed to moist air for several days, it becomes coated with the familiar reddish-brown rust of iron which has also been chemically identified.

Samples of the oxide film from normally fired specimens, heated in air at 1000°F (so that the glass would not soften), were oxidized to red oxide of iron (Fe_2O_3). This also occurs at higher temperatures, although the glass becomes molten. Fe_2O_3 in samples thus treated was detected by qualitative chemical tests and also by petrographic methods.

Thus an oxide film exists between the fired ground-coat enamel and iron, which is reduced to metallic iron in hydrogen and oxidized to Fe_2O_3 in air at temperatures

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Enamel Division). Received April 26, 1938; revised copy received February 9, 1939.

[1] Karl Kautz, "Further Data on Enamel Adherence," *Jour. Amer. Ceram. Soc.*, **19** [4] 93–108 (1936).

[2] J. O. Lord, "A Critical Analysis of Some Statements and Experiments on the Adherence of Sheet-Steel Ground Coats," *ibid.*, **20** [4] 121–24 (1937).

FIG. 1.—Typical oxide film between fired ground-coat enamel and iron; fired 6 minutes; actual size.

FIG. 2.—Reverse pattern showing iron surface from which the oxide film of Fig. 1 was separated; actual size.

below the softening point of the enamel. A substance that behaves in this manner could be only one of the lower oxides of iron, such as FeO, Fe_3O_4, or FeO plus Fe_3O_4.

V. Microscopic Examination

Examinations of the oxide film were made with a comparison microscope with oblique reflected light and a petrographic microscope with polarized light. The petrographic determinations were not conclusive because the finely ground oxide film appeared to consist of dark, opaque masses which did not lend themselves to study by polarized light.

In reflected light, more satisfactory examinations could be made. The structure and characteristics of the oxide film could be studied and compared with that of oxidized iron surfaces. This study showed a definite scale structure in the oxide film on samples variously fired and treated. Figures 3, 4, and 5 (specimens (3) to (9) inclusive), which are photomicrographs taken in oblique reflected light, do not reveal the characteristics of the oxide film as clearly as it is seen visually.

VI. Chemical Analysis

Areas of oxide film on about twenty normally fired specimens (parted as described above) were lightly abraded with a fine-grained SiC stone, and the concentrated oxide film thus obtained was carefully collected and analyzed chemically.

Metallic particles, monoxides, and higher oxides were determined chemically by methods outlined briefly in a previous paper.[3] The results of chemical analysis on this concentrated sample of oxide film are as follows:

	(%)
Fe	0.63
Ni	Tr
Co	Nil
FeO	11.50
NiO	0.37
CoO	0.10
MnO	Tr
Fe_2O_3	2.25
	14.85

Ferric iron is probably present as Fe_3O_4 ($FeO \cdot Fe_2O_3$), because free hematite (Fe_2O_3) could not be identified petrographically in this oxide film.

The undetermined remainder of 85.15% may be regarded as being composed essentially of SiC particles and ground-coat glass particles which loosened during the sampling of the oxide film. Because this analysis represents the composition of a concentrated sample and because only the oxide film is desired, it is permissible to calculate this analysis of the oxide film to 100 parts. The recalculated analysis is as follows:

	(%)
Fe	4.24
Ni	Tr
Co	Nil
FeO	77.45
NiO	2.49
CoO	0.67
MnO	Tr
Fe_2O_3	15.15
	100.00

This analysis may be considered to represent the chemical composition of a typical oxide film between the normally fired ground-coat enamel and the iron.

The fact that 2.49% NiO and 0.67% CoO were found in this oxide film probably indicates a complex structure in which these oxides play a minor rôle.

VII. X-Ray Examination

A portion of the powdered sample, prepared by abrading the oxide-film surface with a SiC stone, was used for the X-ray study made by the fine powder method with MgO as a standard. The developed film showed strong MgO standard lines but weak oxide-film lines; the latter probably was due to the weakly concentrated sample used (see the chemical analysis) and to insufficient exposure. An average of the results of three films is given in Table I.

[3] Karl Kautz, "Chemical Determination of Metallic Particles and Oxides of Iron, Nickel, and Cobalt in Fired Ground Coats," *Jour. Amer. Ceram. Soc.*, **21** [9] 368 (1938).

TABLE I

X-RAY ANALYSIS OF OXIDE FILM*

Line No.	Planar spacings found	Planar spacings due to	Indices	Theoretical planar spacings
1	2.625 A	(?)		
2	2.511	Fe_3O_4	311	2.502 A
3	2.374	(?)		
4	2.027	α Fe	110	2.031
5	1.522	FeO	220	1.519
6	1.428	α Fe	200	1.436
7	1.345	(?)		
8	1.304	FeO	311	1.295
9	1.171	α Fe	211	1.172
10	1.087	Fe_3O_4	553	1.081
11	1.070	FeO	400	1.074
12	1.012	α Fe	220	1.015
13	0.879	FeO	422	0.876

4 identified α-Fe lines: (110), (200), (211), (220).
4 identified FeO lines: (220), (311), (400), (422).
2 identified Fe_3O_4 lines: (311), (553).
3 unidentified lines.

* By fine powder method.

Pask[4] recently made X-ray determinations of the oxide film which was prepared as described in this paper. The method used was to compare the lines obtained on the film with the lines occurring on standard films of Fe, FeO, and Fe_3O_4. The X-ray determination shows the following results:

Line No.	Due to	Line No.	Due to
1	Fe_3O_4 } very close	7	Fe_3O_4
2	Fe_3O_4 }	8	Fe
3	FeO	9	FeO
4	FeO	10	Fe
5	Fe	11	Fe_3O_4
6	FeO	12	Fe

[4] J. A. Pask, Department of Ceramic Engineering, University of Illinois, Urbana, Ill., January, 1938 (not published).

The unidentified lines (1 and 3) of Table I are given by Pask as Fe_3O_4 and FeO, respectively. Lines 2, 4, 5, 6, 8, 9, 10, and 12 of Table I are in close agreement; lines 7 and 11 do not appear on this film; and a new line between 5 and 6 is given as Fe_3O_4. On the whole, the two determinations agree quite well.

These X-ray determinations check the chemical analysis given by the writer, and they show positively that α-Fe, FeO, and Fe_3O_4 are present in the oxide film formed between the ground-coat enamels and the sheet iron fired in air.

VIII. Discussion

The method described in this study of separating the fired enamel layers from the iron base permits direct tests and examinations to be made upon the oxide film exposed.

Alcoholic stannous chloride is used in the study of inclusions in steel because it readily etches FeO or mixtures rich in FeO. Highly polished enameling iron is not etched, nor is pure magnetite (Fe_3O_4) when treated with this solution for five minutes. Mill scale is etched by this solution, but because it is a mixture of FeO plus Fe_3O_4 it should show a reaction. Ground-coat enamel fired on platinum is not etched by this solution. The solution, however, penetrates cracks in the enamel and makes them easily visible. This test with alcoholic stannous chloride is merely a qualitative test which indicates the presence of FeO.

The reduction and oxidation tests prove (1) that the exposed oxide film is composed of iron oxides (not necessarily FeO) because metallic iron is formed by reduction and (2) that the exposed oxide film is composed of iron oxides of a lower state of oxidation than Fe_2O_3 because they are altered by oxidation to Fe_2O_3.

The recalculated analysis shows 2.49% NiO and 0.67% CoO but only a trace of MnO. What does this mean? The content of MnO in this enamel was more

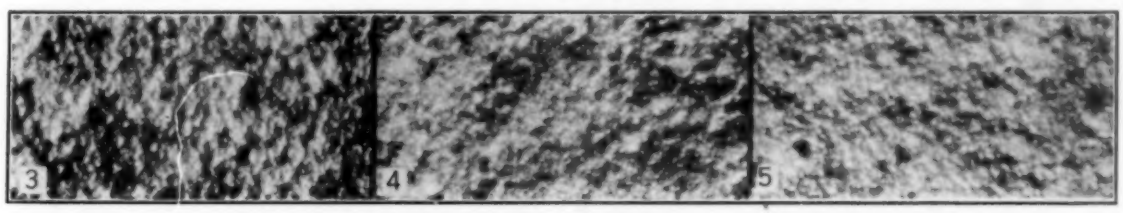

FIG. 3.—(3) Character of oxide film under ground coat fired 2 minutes, ×100 (oblique reflected light); (4) character of oxide film under ground coat fired 6 minutes, ×100 (oblique reflected light); (5) character of iron surface from which oxide film of (4) was removed, ×100 (oblique reflected light).

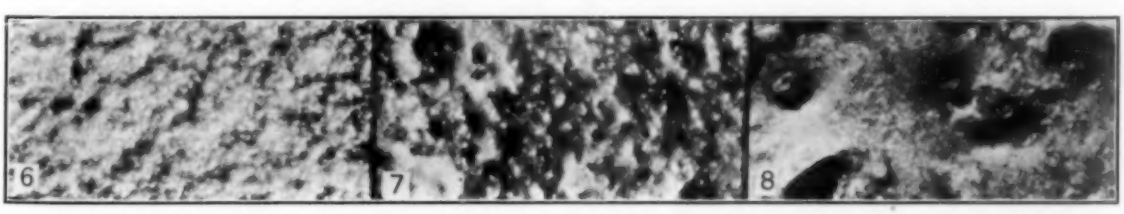

FIG. 4.—(6) Oxide film under ground coat fired 20 minutes, ×100 (oblique reflected light); (7) parted ground coat fired 60 minutes, ×100 (oblique reflected light); (8) oxide film reduced to Fe in hydrogen at 1000°F, ×100 (oblique reflected light).

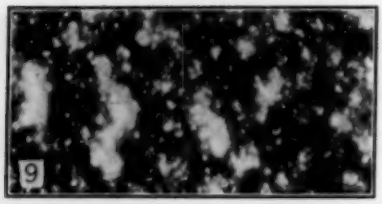

FIG. 5.—(9) Oxide film oxidized to Fe_3O_4 in air at 1200°F, ×100 (oblique reflected light).

than double that of cobalt oxide or nickel oxide, but only a trace of it shows in this analysis. If the nickel and cobalt oxides found come from the enamel by solution in the reagent, why was manganese oxide not equally attacked. A possible explanation is that the nickel and cobalt oxides that were found may exist as free oxides in this complex oxide film, being thrown out of their glass solution by iron oxides during firing, and that manganese oxides still remain as glass solutions and are not attacked by the reagent. The exposed oxide film attached to the enamel is extremely thin and as such does not give a satisfactory X-ray pattern. Even after concentrating the oxide film as much as possible by abrading the exposed surface with an abrasive stone, the X-ray lines were faint or weak. Check determinations were made with increased exposures, which increased the intensity of the lines very little. All three determinations were in close agreement and showed Fe, FeO, and Fe_3O_4 unquestionably to be present in the oxide film.

IX. Summary

The oxide film between fired ground-coat enamel and iron was studied at close range by "sticking" enameled iron specimens together at 1600°F and tearing them apart when cold. This treatment frequently exposed an oxide film which contained FeO as one constituent. The presence of FeO in the oxide film was indicated by the etching produced by alcoholic stannous chloride. That the film contained FeO or Fe_3O_4, or both, is shown by the fact that (1) hydrogen reduced it to metallic iron and (2) air oxidized it to ferric oxide (Fe_2O_3), both at temperatures below the softening point of the enamel.

Microscopic examination of the oxide film revealed a typical iron-scale structure. Chemical analysis showed this oxide film to be composed essentially of FeO with smaller amounts of Fe_3O_4 and Fe. X-ray examinations of this oxide film showed four FeO lines, four α-Fe lines, two Fe_3O_4 lines, and three unidentified lines.

Acknowledgment

The author wishes to acknowledge his indebtedness to W. J. McCaughey, Department of Mineralogy, Ohio State University, Columbus, Ohio, for the use of the X-ray equipment of his laboratory and to A. I. Andrews and J. A. Pask, Department of Ceramic Engineering, University of Illinois, Urbana, Ill., who made a number of X-ray determinations on the oxide film to check the results obtained in this study. Acknowledgment is also given to the assistance of L. J. Pottorf, Republic Steel Corporation, Massillon, Ohio, who made the chemical determinations.

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OBSERVATIONS ON THE FUNCTION OF ADHERENCE-PROMOTING OXIDES IN GROUND-COAT ENAMELS*

BY KARL KAUTZ

ABSTRACT

Five enamels were smelted which contained (*a*) no adherence-promoting oxides, (*b*) 0.5% Co_3O_4, (*c*) 0.5% NiO, (*d*) 1.0% MnO_2, and (*e*) all three oxides. A study was made of the effect of these oxides in the enamel upon (1) the adherence to sheet iron, (2) the iron oxides formed between the enamel and iron base, and (3) the ability of the enamel to carry or transmit oxygen from the air to the iron base. The results obtained show that cobalt oxide promotes adherence, allows heavy films of iron oxide to form at the surface of the iron, and accelerates penetration of aerial oxygen through the molten enamel layer. Nickel oxide behaves like cobalt oxide, but it is much weaker. The results show that manganese oxide does not promote adherence, allows no iron-oxide films to form, and has a slight effect only upon the penetration of aerial oxygen through the molten enamel layer.

I. Introduction

Investigators of porcelain enamels have reached the conclusion that successful commercial ground-coat enamels must contain small amounts of cobalt oxide, together with other metallic oxides, usually nickel and manganese. Many theories have been proposed to explain the action of these so-called adherence-promoting oxides in ground-coat enamels. Inasmuch as they actually do function in the adherence of enamels to iron, any theory of adherence must necessarily consider these oxides and their rôle in ground-coat enamels.

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Enamel Division). Received April 26, 1938; revised copy received February 9, 1939.

II. Composition and Preparation of Enamels

An enamel with the following smelting batch (exclusive of adherence-promoting oxides) was chosen:

Borax	33.0
Feldspar	28.0
Quartz	20.0
Soda ash	8.0
Sodium nitrate	5.0
Fluorite	6.0
	100.0

To 100 parts of this batch, the additions were made before smelting as follows:

Enamel No.	(%)
1	No additions
2	0.5 Co_3O_4
3	0.5 NiO
4	1.0 MnO_2
5	0.5 Co_3O_4, 0.5 NiO, 1.0 MnO_2

These frits were milled in laboratory ball mills with the following mill batch: frit 100.0, clay 7.0, borax 0.75, and water 45.00.

To maintain a uniform thickness of ground coat on the specimens, the milled enamels were set up as uniformly as possible. The dipping weights (after drying) in grams per square foot were determined as follows: enamel No. 1, 34.6; No. 2, 35.0; No. 3, 34.8; No. 4, 34.8; and No. 5, 35.2.

These milled enamels were fused on platinum foil and were analyzed chemically for total iron oxides in the enamel. The results (expressed as FeO) were as follows: enamel No. 1, 0.28%; No. 2, 0.25%; No. 3, 0.24%; No. 4, 0.23%; and No. 5, 0.25%.

III. Physical Tests on Fired Enamels

The milled enamels were applied to 20-gauge, 6- by 8-inch enameling iron samples, which had been given identical cleaning and pickling treatments and fired at 1600°F for $1^1/_2$ and for 6 minutes.

Bending Tests: The samples fired $1^1/_2$ minutes were bent and flexed to study the amount of initial scale formed during the heating-up period. Enamel No. 1 showed little initial scale; No. 4, practically none; and Nos. 2, 3, and 5, the usual amounts of initial scale formed during this firing.

Impact Tests: Impact tests were made on samples fired 6 minutes, and the adherence was rated visually as follows: enamel No. 1, poor; No. 2, good; No. 3, fair; No. 4, very poor; and No. 5, very good. Photographs of typical impact tests at a 1.25 magnification are shown in Fig. 1, Nos. (1), (4), (7), (10), and (13).

Sticking Tests: Samples fired 6 minutes were "stuck" together when reheated at 1600°F for several minutes and then pulled apart when cold. The amount of oxide film thus exposed was graded visually as follows: enamel No. 1, very light; No. 2, heavy; No. 3, medium heavy; No. 4, practically none; and No. 5, heavy. Photographs of typical oxide films at a magnification of 1.25 are shown in Fig. 1, *viz.*, Nos. (2), (5), (8), (11), and (14). Photomicrographs of typical oxide films at a magnification of 75 with dark field illumination are also shown in Fig. 1, *viz.*, Nos. (3), (6), (9), (12), and (15).

(1) Effect of Adherence-Promoting Oxides in Enamel upon Adherence to Iron

Figure 1, Nos. (1), (4), (7), (10), and (13), shows the effect of the various additions upon the adherence as given by impact tests. The only variable or difference between the enamels was the content of adherence-promoting oxides. Enamel No. 1 showed extremely poor adherence; the enamel parted from the iron base clean and in large flakes with quite an area affected. The addition of 0.5% Co_3O_4 (enamel No. 2) caused an enormous increase in adherence. The depression showed much oxide and enamel remaining after the impact.

The conclusions drawn from these tests are as follows (see Fig. 1): (*a*) clear enamel, extremely poor adherence to iron (1); (*b*) 0.5% Co_3O_4 addition, greatly increased adherence (4); (*c*) 0.5% NiO addition, increased adherence moderately (7); (*d*) 1.0% MnO_2 addition did not improve or increase adherence (10); (*e*) 0.5% Co_3O_4, 0.5% NiO, and 1.0% MnO_2 additions greatly increased adherence. Enamel No. 5 showed slightly better adherence than No. 2, which contained only 0.5% Co_3O_4.

(2) Effect of Adherence-Promoting Oxides in Enamel upon Formation of Iron-Oxide Films

A careful study and comparison of Fig. 1, Nos. (2), (5), (8), (11), and (14), shows that (*a*) clear enamel (2) caused an extremely light film of iron oxide to form (this film was almost transparent and had a slight gray color); (*b*) addition of 0.5% Co_3O_4 (5) caused a heavy film of iron oxide to form (this film was very opaque and almost black); (*c*) addition of 0.5% NiO (8) caused a medium film of iron oxide to form (this film was opaque and dark gray, much lighter in color than that produced by Co_3O_4); (*d*) addition of 1.0% MnO_2 (11) did not cause the formation of an iron-oxide film (this film was transparent and almost colorless); and (*e*) addition of 0.5% Co_3O_4, 0.5% NiO, and 1.0% MnO_2 (14) caused a heavy film of iron oxide to form (this film was very opaque and almost black in color).

(3) Relation Between Adherence and Iron-Oxide Film

A comparison of the impact-test depression and the oxide film for each enamel showed that adherence is definitely connected or related to the amount or character of the iron-oxide film between the enamel and the iron base. The poor adherence of enamel No. 1, Fig. 1 (Nos. (1) and (2)), seems to be directly related to the very light iron-oxide film formed. The very good adherence of enamel No. 2 (Nos. (4) and (5)), seems to be related to the heavy iron-oxide film formed under this enamel. The mediocre adherence of enamel No. 3 (Nos. (7) and (8)) seems to be influenced by the medium oxide film formed under this enamel. Enamel No. 4 (Nos. (10) and (11)) had the poorest adherence of all as shown by the impact test, the "lift spots," and fishscales. In this case, however, there

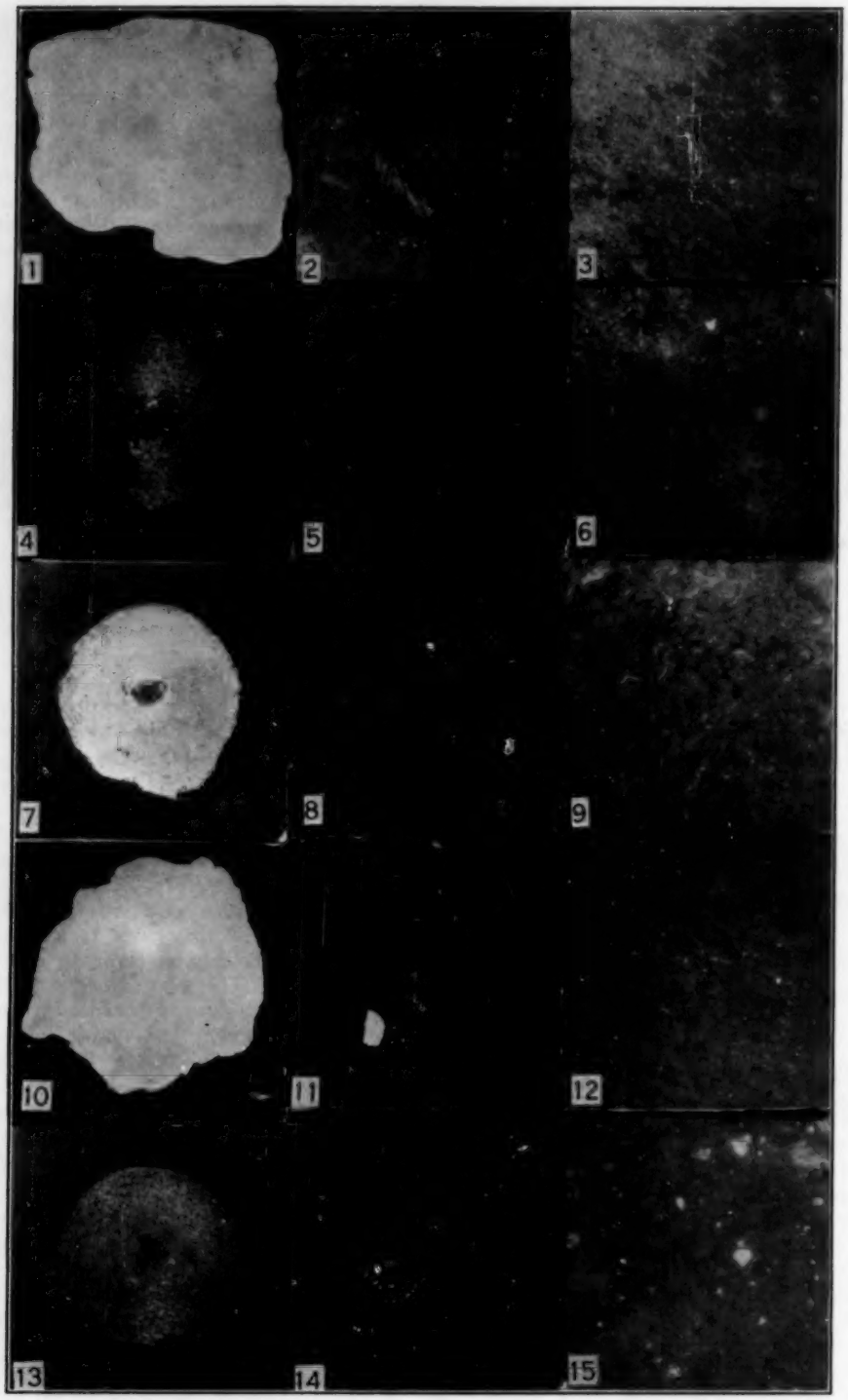

FIG. 1.—Enamel No. 1 (no adherence-promoting oxides): (1) impact test depression, ×1.25; (2) oxide film, ×1.25; (3) oxide film, ×75. (Dark field illumination used throughout.)
Enamel No. 2 (0.5% Co_3O_4): (4) impact test depression, ×1.25; (5) oxide film, ×1.25; (6) oxide film, ×75.
Enamel No. 3 (0.5% NiO): (7) impact test depression, ×1.25; (8) oxide film, ×1.25; (9) oxide film, × 75.
Enamel No. 4 (1.0% MnO_2): (10) impact test depression, ×1.25 (note fishscales and lift spots in this specimen); (11) oxide film, ×1.25; (12) oxide film, × 75.
Enamel No. 5 (all oxides): (13) impact test depression, ×1.25; (14) oxide film, ×1.25; (15) oxide film, ×75.

was no iron-oxide film or the film was so thin that it was transparent. The adherence of enamel No. 5 (Nos. (13) and (14)) was very good and the iron-oxide film was correspondingly very heavy. It can not be said, however, that the heavier the oxide film, the better the adherence, because underfired specimens usually show very thick oxide layers, but they have poor adherence. It seems that adherence increases with the thickness of the iron-oxide film only up to a limiting value beyond which it rapidly decreases. Both the chemical composition and the physical properties of the iron-oxide film probably play an important rôle in its adhesion to the iron surface. The oxide film, which forms by secondary oxidation through the molten enamel layer, may be much richer in FeO than the initial scale, formed by direct oxidation of the iron by air.

IV. Chemical Analyses of Fired Enamels

The enamel from specimens fired 6 minutes in air at 1600°F was removed by flexing and bending the specimens. These flakes, or splinters, were analyzed chemically by methods outlined briefly in a previous paper.[1]

(1) Free Iron-Oxide Film

Attempts to analyze the free iron-oxide film adhering to the enamel fragments were unsuccessful. These results were very erratic, probably owing to the highly soluble nature of the enamel used. This enamel was quite soluble in water and even more so in the weak acid solution used for dissolving the oxide film.

(2) Total Iron Oxides in and Adhering to Enamel

The results of these chemical analyses (average of two determinations) are given in Table I, column (2), in which the total iron oxides found are expressed as FeO. The values of column (3), the net total iron oxides formed during firing, were obtained by deducting the iron oxides originally present in the milled enamels from the total iron oxides of column (2).

TABLE I

(1) Enamel No.	(2) Total iron oxides (%)	(3) Net total iron oxides (%)
1	6.34	6.06
2	8.64	8.39
3	8.23	7.99
4	6.76	6.53
5	9.06	8.81

The effect of adherence-promoting oxides in the enamels upon the total iron oxides formed during firing is shown in Table I. Cobalt oxide (enamel No. 2) caused considerably more iron oxides to form than the clear enamel, No. 1. Nickel oxide likewise increased the amount of iron oxides but not as much as cobalt oxide. Manganese oxides caused but little increase in the amount of iron oxides, and all three oxides caused the greatest amount to form.

[1] Karl Kautz, "Chemical Determination of Metallic Particles and Oxides of Iron, Nickel, and Cobalt in Fired Ground Coats," *Jour. Amer. Ceram. Soc.*, **21** [9] 307–11 (1938); p. 308.

The results of Table I show that more total oxidation occurs during firing when cobalt or nickel oxides are present in the enamel. Oxidation in the firing of ground coats may be divided into two stages: (1) primary oxidation, which forms by direct action of aerial oxygen upon the iron base before the enamel frit particles are sintered or melted together, and (2) secondary oxidation, which takes place after fusion of the enamel. It is not likely that primary oxidation is greatly influenced by cobalt or nickel oxides in the unmelted coat, but it is probable that secondary oxidation may be greatly affected.

V. Effect of Adherence-Promoting Oxides in Enamel upon Secondary Oxidation

A study of the total iron oxides formed during firing (Table I) showed quite a variation in the amount of iron oxides with the different adherence-promoting oxides. This observation led to the belief that secondary oxidation may be greatly affected by these adherence-promoting oxides in the enamels.

(1) Method

Two samples of ground-coated iron were fired side by side in air at 1600°F until completely glossed (2 minutes) and were removed from the furnace. One of these samples was reheated for 6 minutes and removed.

The difference between the total iron-oxide content of the two samples gives the amount of iron oxide formed by secondary oxidation, *i. e.*, by penetration of aerial oxygen through the molten enamel.

(2) Procedure

Ten samples of 24-gauge enameling iron, 6 by 8 inches, were prepared for enameling in the usual manner. The five special enamels (Nos. 1 to 5) were applied to two samples each at the dipping weights previously given and were fired in air at 1600°F in like pairs for 2 minutes. This procedure allowed the enamels to become completely glazed, thus protecting the iron surface from further direct oxidation by air. One sample of each enamel was then refired in air at 1600°F for an additional 6 minutes. The enamels were removed from the iron base by flexing and bending double, and all fragments were carefully collected. The amount of total iron oxides in and adhering to each enamel at each firing interval was determined chemically.

(3) Results

These results and the numerical difference between the two determinations are given in Table II (the iron-oxide content is expressed as FeO).

TABLE II

Enamel No.	Total iron oxides fired 8 minutes (%)	Total iron oxides fired 2 minutes (%)	Iron oxides formed by secondary oxidation (%)
1	7.77	5.47	2.30
2	10.82	6.04	4.78
3	9.87	5.95	3.92
4	8.15	5.40	2.75
5	11.95	6.91	5.04

(4) Discussion of Results

A study of the results given in Table II shows that secondary oxidation (penetration of aerial oxygen through the molten enamel layer) is greatly aided or accelerated by cobalt and nickel oxides in the enamel. Manganese oxide causes little increase in secondary oxidation over the clear enamel, but cobalt oxide in the enamel shows more than twice as much oxidation as clear enamel. Nickel oxide in the enamel also shows a large increase in secondary oxidation over the enamel containing no adherence-promoting oxides. The effect of all three of these oxides present in the enamel at once is seen by comparing enamel No. 5 with enamel No. 1, an increase of almost 120% in the formation of iron oxides by secondary oxidation.

VI. Summary

The results of this investigation are summarized briefly in the following paragraphs:

Cobalt oxide greatly aids adherence, allows heavy iron-oxide films to form between the enamel and iron, and accelerates the penetration of aerial oxygen through the molten enamel during firing.

Nickel oxide increases adherence slightly, allows medium iron-oxide films to form between the enamel and iron, and accelerates penetration of aerial oxygen through the molten enamel during firing.

Manganese oxide hinders adherence, allows slight or no oxide film to form between the fired enamel and iron, and has only a slight effect upon the penetration of aerial oxygen through the molten enamel during firing.

The effect of all three oxides in the enamel is to make an enamel that has very good adherence to iron, allows heavy iron-oxide films to form between the enamels and iron, and greatly accelerates the penetration of aerial oxygen through the molten enamel during firing.

Nickel oxide acts like cobalt oxide in all respects, but is much weaker, perhaps only 25% as effective.

The results also indicate that the amount and character of the iron-oxide film influences the degree of adherence.

VII. Discussion

One of the reasons why cobalt oxide (or nickel oxide) is necessary in successful ground coats is because it accelerates penetration of aerial oxygen through the molten enamel layer. This is desirable in ground coats in order to oxidize the iron surface continuously during firing.

The results of chemical analyses on the free oxide film have not been given because they were so erratic. A study of these analyses, however, has led to the belief that manganese oxide promotes absorption or solution of iron oxides in the enamel. This is further shown by the fact that free iron-oxide films do not form under enamels containing manganese oxide, although considerable iron oxide is found by analysis.

The composition of the base enamel affects its solvent power for iron oxides to some degree. Some enamels are probably such good solvents that manganese oxides need not be used. Other compositions may need considerable amounts of manganese oxides to effect proper absorption of iron oxides.

Another surprising fact is the amount of secondary oxidation occurring with the clear enamel. This indicates that some ingredient of the clear enamel is also probably acting as an oxygen carrier. B_2O_3 is suspected of playing such a rôle because of its ability in the glassy state to have either triangular or tetrahedral coördination, depending upon the amount of Na_2O present.[2]

The rôle of cobalt and nickel compounds as oxygen carriers is not without parallel in chemical phenomena. Solutions of hypochlorous acid (HClO) are quite readily decomposed, with the evolution of oxygen, when cobalt oxide or a salt of cobalt is added to them. Compounds of nickel decompose these hypochlorous-acid solutions almost as well as cobalt compounds. The cobalt compounds probably act as catalytic agents. Mellor[3] says that "the mechanism of the reaction is generally supposed to involve the concurrent reactions corresponding with the transformations of the cobalt oxide,

$$CoO \longrightarrow Co_2O_3 \longrightarrow CoO \longrightarrow Co_2O_3 \longrightarrow \text{etc.}"$$

In other words, cobaltic oxide (Co_2O_3) acts as an oxygen carrier owing to the ease with which it is formed and decomposed.

Because CoO, Co_3O_4, and Co_2O_3 each form blue-colored glasses, as evidenced by a cobalt-borax bead in oxidizing and reducing flames, it is impossible to detect by visual observations whether an enamel contains cobalt in the lower or higher state of oxidation. It is possible that ground-coat enamels contain both cobaltous and cobaltic oxides in solution. Inasmuch as cobaltic oxide yields oxygen so readily, it is not unreasonable to assume that, in contact with metallic iron at enameling temperatures, it yields this oxygen to the easily oxidizable iron base.

The rapidity with which oxygen is carried through molten ground coats is illustrated by a simple experiment.

(1) Experiment

A sample of ground-coat enamel fired on iron in air at 1600°F for 6 minutes was reheated in hydrogen at 1600°F until all of the iron oxide formed was again reduced to metallic iron; time required, $1^1/_2$ hours.

Here hydrogen, with the smallest molecule known and a gas which readily diffuses through most metals at high temperatures, required $1^1/_2$ hours to reduce by diffusion through the molten enamel layer the iron oxides which formed by firing in air only 6 minutes. Because oxygen has a molecule many times larger than hydrogen, it is hardly possible that the rapid secondary oxidation occurring in the firing of ground-coat enamels is due to diffusion, as such, of oxygen molecules through the enamel.

The mechanism of secondary oxidation might, therefore, be due to some sort of conduction or exchange of

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[2] J. Biscoe and B. E. Warren, "X-Ray Diffraction Study of Soda-Boric Oxide Glass," *Jour. Amer. Ceram. Soc.*, **21** [8] 287–93 (1938).

[3] J. W. Mellor, Modern Inorganic Chemistry, p. 336. Longmans, Green, & Co., New York, 1934.

oxygen atoms through the molten ground-coat layer. It may be that molecules of aerial oxygen in contact with the outer molten enamel surface are absorbed by cobaltous solutions to form cobaltic solutions, which in turn impart their oxygen to cobaltous solutions located internally and so on until the iron surface is reached.

The cobalt content of normally fired molten ground coats on iron might thus exist as cobaltic solutions at the outer surface and grade inwardly through various mixtures to cobaltous solutions in contact with the iron surface. Nickel oxide, it is believed, might act in a like manner.

VIII. Conclusions

The following conclusions are drawn from this investigation:

(1) One of the rôles of cobalt oxide (and nickel oxide) in ground coats is to act as an oxygen carrier.

(2) The iron-oxide film, which forms between the enamel layer and the iron base, definitely affects the adherence of the enamel.

(3) A well-balanced ground coat should have the proper amounts of adherence-promoting oxides incorporated in it so that a fairly heavy iron-oxide film is maintained between the enamel and iron during firing.

Acknowledgments

The writer wishes to thank the Chicago Vitreous Enamel Product Company of Cicero, Ill., for furnishing and smelting the special enamels used in this investigation and also wishes to acknowledge the assistance of L. J. Pottorf, Republic Steel Corporation, Massillon, Ohio, who made the chemical determinations quoted in this paper.

Republic Steel Corporation
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EFFECT OF FURNACE GASES ON PHYSICAL PROPERTIES OF WET-PROCESS CAST-IRON ENAMELS*

By G. H. Spencer-Strong

Abstract

Lead-bearing and leadless cast-iron enamels, applied directly on the iron, and leadless enamels, applied over a ground coat, were fired in normal, low oxygen-high nitrogen, high carbon dioxide, and high water-vapor atmospheres, and the effect upon the surface and physical properties in relation to impact and thermal resistance was determined. The enamels in some cases were applied over graphited castings, fired in the several atmospheres, and tested. The behavior of different types of enamel fired in various atmospheres differs, the leadless enamel applied over ground coat showing the least effect. High water-vapor content appears generally to be more deleterious than the other atmospheric conditions.

I. Introduction

Enamelers of cast iron not infrequently encounter mysterious difficulties with their products which might readily be connected with furnace-atmosphere conditions if encountered in sheet-iron enamels. Because of the peculiarities of cast-iron enameling, however, these defects might be blamed on the iron. Thus, one type of casting may blister or show poor adherence, and a casting of a different design in the same enamel will show no defects whatsoever. Although this irregularity of behavior at first might appear to be due to iron characteristics and design, the experiences of some enamelers have indicated that in some cases furnace atmospheres may be partially or wholly to blame.

II. Literature

From time to time during the past fifteen years, the enamel industry has been reminded that furnace atmospheres have considerable influence in the formation of many of the defects encountered in the industry. Various phases of the problem have been studied,* and a survey of published work indicates that faulty furnace atmosphere may give rise to blisters, copperheads, poor adherence, reboil, and loss of gloss with sheet-iron enamels, and blistering and loss of gloss in cast-iron enamels. The data do not indicate the study of any particular cast-iron enamel; they fail, in fact, to give any details about such enamels except that they were affected. There are also no data presented as to any defects encountered in cast iron other than those apparent to visual inspection.

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Enamel Division). Received May 17, 1938.

* See next page for footnote 1.

III. The Problem

In view of the tendency in recent years toward the use of leadless enamels for cast iron directly over the iron and over the ground coats and with the accumulation of information from the field which indicates that furnace atmospheric conditions might well be the cause of certain cast-iron defects not previously attributed thereto, studies have been made on the effect of certain furnace-atmosphere constituents upon all three types of cast-iron enamels from the standpoint of visible defects as well as of the effect of the gases upon some of the physical properties of the enamels.

IV. Method and Procedure

(1) Enamels

Regular commercial, wet-process enamels of the lead and leadless types direct on the iron and of the leadless type over ground coats were used. The enamels were milled with regular commercial formulas and were applied in two coats of 41 grams per square foot each. The firing treatment is shown in Table I.

TABLE I

FIRING TREATMENT OF ENAMELS

No.	Type	Firing time (minutes)	Firing temp. (°F)
A	Lead	19	1280–90
B	Leadless	15	1350
C–1	Leadless ground coat	20	1400
C–2	Leadless cover coat for C–1	15	1350

For simplicity, the combination of enamel C–2 over C–1 has been designated in the remainder of the paper as "enamel C."

(2) Gases

Inasmuch as an investigation such as the present one offers almost unending possibilities for the use of gases, in combination and in concentrated form, the gases studied were limited to those most frequently encountered in practice and the concentration was limited to values approximating the most severe conditions found in actual practice. The most common gases, aside from the oxygen and nitrogen of the air in enameling furnaces, are the flue gases, *viz.*, carbon dioxide and water vapor, encountered in fuel-fired furnaces, and water vapor alone, encountered in electric furnaces and under some conditions in other types. Sulfur dioxide may be encountered in fuel-fired furnaces, but it is recognized by the scumming condition it engenders. Another condition which has given considerable trouble in some sheet-iron enameling plants, owing to the lack of a gas rather than to its excess, is oxygen deficiency.

Although troubles in enameling cast iron caused by flue gas and water vapor have been noted in the literature, there is no specific mention of the effect of oxygen deficiency. Inasmuch as the presence of excess carbon dioxide and water vapor would depress the oxygen content of the furnace atmosphere, some studies were made with an atmosphere containing an excess of nitrogen and a deficiency of oxygen. Although water vapor is always present in furnace atmospheres containing carbon dioxide, usually in amounts at least twice the CO_2 content, the effects of atmospheres adulterated with CO_2 and with water vapor alone as well as in the usual combination were studied in order to give comparative values.

The atmospheres studied were (*a*) normal, (*b*) 90% N_2 to 10% O_2, (*c*) 8% CO_2, (*d*) 3 to 5% H_2O, and (*e*) 3% and 5% H_2O.

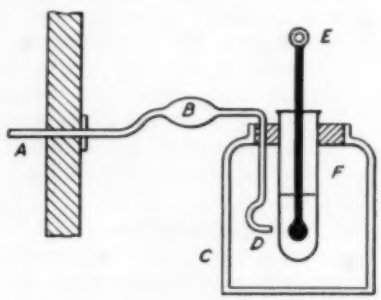

FIG. 1.—Dew point humidometer.

(3) Sample Plates

Cast-iron sample plates, 3½ by 5 inches, were used throughout the investigation. The plates were chosen from a single shipment and were carefully inspected for their uniformity of thickness of section, weight of plate, and absence of irregularities and warping. The plates were blasted at the same time and were stored in a special moisture-proof box. In some cases before enameling, an extremely light dust of graphite was applied over the plates to simulate conditions occasionally encountered in the industry where there is a formation of Kish or fine graphite on the surface

[1] (*a*) R. D. Cooke, "Effect of Furnace Atmosphere on the Firing of Enamel," *Jour. Amer. Ceram. Soc.*, **7** [4] 277–81 (1924).
(*b*) Symposium, "Effect of Muffle Atmosphere on Firing Enamels," *Bull. Amer. Ceram. Soc.*, **3** [11] 437–42 (1924).
(*c*) H. H. Clark, "Gas-Fired Enameling Furnaces Without Muffles," *Jour. Amer. Ceram. Soc.*, **8** [10] 623–25 (1925).
(*d*) A. I. Andrews and E. A. Hertzell, "Progress Report on Effect of Furnace Gases on Quality of Enamels," *ibid.*, **13** [8] 522–29 (1930).
(*e*) H. E. Ebright and G. H. McIntyre, "Effect of Water Vapor on Porcelain Enamel During Firing," *Enamelist*, **10** [6] 11–13 (1933); *Ceram. Abs.*, **12** [8] 293 (1933).
(*f*) J. T. Irwin, "Furnace Firing Conditions Checked," *Enamelist*, **12** [4] 18–19 (1935); *Ceram. Abs.*, **14** [4] 87 (1935).
(*g*) W. G. Leslie, "Adequate Venting of Enameling Furnaces," *Better Enameling*, **4** [4] 9 (1933); *Ceram. Abs.*, **12** [8] 293 (1933).
(*h*) H. E. Ebright, G. H. McIntyre, and J. T. Irwin, "Study of Furnace Atmospheres and Temperature Gradients and Their Effect on Porcelain Enameling," *Jour. Amer. Ceram. Soc.*, **18** [10] 297–302 (1935).
(*i*) G. H. McIntyre, "Influence of Furnace Gases on Porcelain Enameling," *Enamelist*, **14** [4] 6–10 (1937); *Ceram. Abs.*, **16** [6] 169 (1937).

of the iron (see Table III). Although this condition is not truly a part of the present problem, it seemed to be desirable to determine whether or not the presence of Kish would accentuate any defects caused by furnace atmosphere conditions.

Enamels A, B, and C, as noted in Table I, were applied in two coats of 41 grams per square foot each (except ground coat C–1, which was applied at approximately 20 grams per square foot).

(4) Test Furnace

An electrically heated laboratory furnace with muffle dimensions of 5 by 8½ by 15 inches was used for all tests. Two samples were fired at a time. Gas was introduced through a perforated tube lying on the floor parallel to the length of the furnace about ½ inch below the sample plates. Gas-analysis samples were removed by inserting a sampling tube through the peephole in the furnace door to a position just above the sample plates.

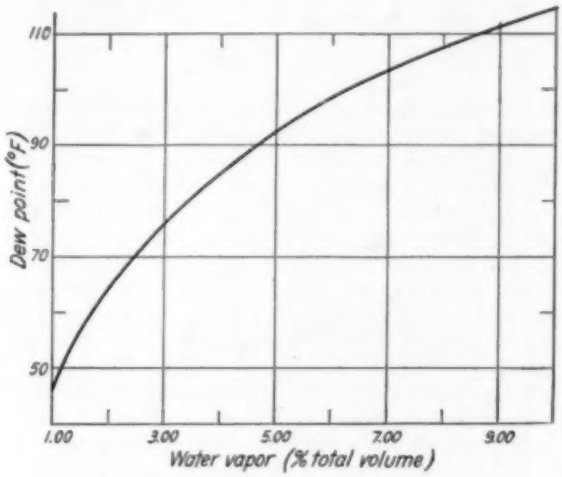

FIG. 2.—Dew point-water vapor relationship.

(5) Gas Analysis

Gases other than water vapor were analyzed with a standard Orsat gas-analysis apparatus. The water-vapor content was determined with a dew-point humidometer (Fig. 1). Because the rapid determination of the water-vapor content in furnace atmspheres has not been easy for the average plant man to make and because this apparatus is extremely simple in design and operation, a description of it is given. The principle of the dew-point humidometer consists simply of cooling a polished surface progressively in a stream of the gas under test until a fog or dew appears on the chilled surface, at which time the temperature is taken. Inasmuch as the temperature is that at which the gas under test is saturated with moisture, reference to that temperature on a good psychrometric chart will show the relative volume of dry air and saturated air at that temperature and the percentage of water vapor may be readily determined. A curve for general use, such as that shown in Fig. 2, may be set up easily so that the water-vapor content may be determined at a glance. In the present case (Fig. 1), a large test tube suspended in a bottle was used as the mirror surface. Water at a temperature of about 120°F was placed in the tube and cold water was added progressively. Furnace gas was pumped into the apparatus by the suction bulb, *B*, through the tube, *D*, against the chilled surface, *F*, until the dew point was reached. This instrument may appear to be a little crude compared to similar instruments recently placed on the market, but it is simple and inexpensive and is sufficiently accurate for general plant use. With all instruments of this type, care must be taken that the gases coming from the furnace are not cooled below the dew point because in such case some of the moisture may be lost before the gases reach the chilling surface.

(6) Testing of Samples

Enameled test samples were subjected to visual examination and to impact and thermal-resistance tests. Impact tests were made in a pendulum-type impact machine, using increasing blows in increments of 0.05 foot-pound until the piece failed. Thermal-resistance tests were made by placing the sample plate on an 8-inch tripod stand over a Bunsen burner with the tip of the inner cone of the burner just touching the specimen. Temperature of failure by crazing and hairlining was noted.

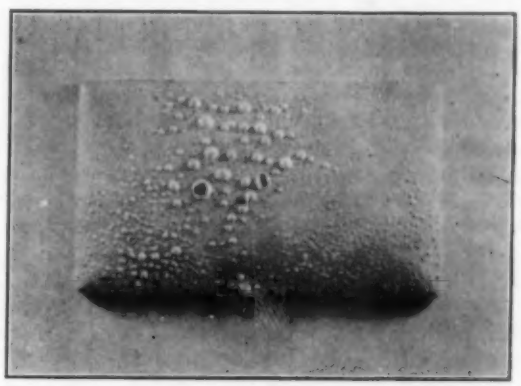

FIG. 3.—Blistering defect in lead-bearing cast-iron enamel due to 5% water vapor in furnace atmosphere (½ natural size).

V. Data and Results

(1) Carbon Dioxide

Carbon dioxide without water vapor caused enamel A to become very spongy and enamel B to become slightly spongy, but it had no effect on the surface characteristics of enamel C. Impact resistance and thermal shock resistance were increased markedly in all cases. When the enamels were applied over graphited castings and fired in carbon dioxide, the sponginess of enamels A and B was increased. Physical properties tested higher than those of graphited castings fired in normal atmosphere.

TABLE II

EFFECT OF ATMOSPHERES ON CAST-IRON ENAMELS

Gas added to furnace atmosphere (type)	(% added)	Impact and resistance (ft.-lb.)	Thermal resistance: Crazing temp. (°F)	Thermal resistance: Hairlining temp. (°F)	Surface appearance
		Enamel A			
Normal		2.02	216	358	
CO_2	8	2.60	388	458	Spongy
H_2O	5	Blistered too badly for test			
N_2	10	1.89	400	470	Slight roughing
CO_2 and H_2O	3 and 5	1.82	510	570	Blistered
		Enamel B			
Normal		1.72	540	600	
CO_2	8	2.20	590	640	Slightly spongy
H_2O	5	1.40	No failure at 1000°		Pop-offs, fine blisters, black specks
N_2	10	1.62	638	760	Bad black specks
CO_2 and H_2O	3 and 5	1.57	470	530	Black specks
		Enamel C			
Normal		1.31	344	390	
CO_2	8	1.93	412	484	No defects
H_2O	5	1.07	480	568	"
N_2	10	1.45	532	672	"
CO_2 and H_2O	3 and 5	1.45	500	576	"

(2) Water Vapor

Violent blistering occurred in enamel A when fired in an atmosphere containing 5% water vapor (Fig. 3). A similar defect has often been noted on production ware. Reduction of the concentration to 3% reduced the size of the blisters. Enamel B showed popping-off, fine blisters, and some black specks when fired in water vapor; enamel C was not visibly affected. Enamel A was blistered too badly to test. Enamel B showed decreased impact resistance but greatly increased thermal resistance; enamel C also showed decreased impact resistance and increased thermal resistance. Many of the test samples showed the same impact resistance as similar enamels in practice.

(3) Nitrogen

The reduction of the oxygen content of the furnace atmosphere to 10% by the addition of nitrogen did not affect the surface characteristics of enamel A except for a slight roughing of the surface. Enamel B showed a marked tendency to blackspeck (Fig. 4). These specks appeared as raised black dots in the center of a depression. Enamel C was not visibly affected. Nitrogen decreased the impact resistance of enamels A and B, but it increased the thermal resistance. Enamel C showed slightly increased impact resistance in the nitrogen atmosphere and greatly increased thermal resistance. Graphite with the nitrogen atmosphere gave rise to pinholing with enamel A and very bad blackspecks with enamel B. Impact resistance of enamel A with graphite in nitrogen was increased, that of enamel B decreased, and that of enamel C unchanged. Thermal resistance was greatly increased in all cases.

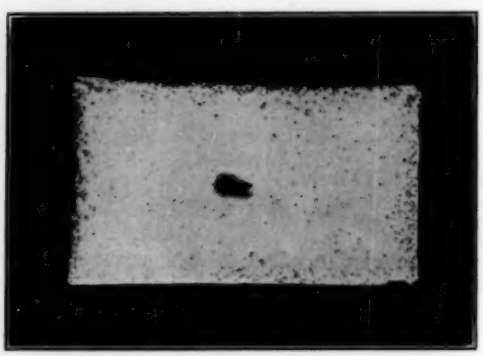

FIG. 4.—Black specking defect in leadless enamel directly on the cast iron due to reduction of oxygen content of air by the addition of 10% nitrogen (1/3 natural size).

(4) Water Vapor and CO_2

The mixture of water vapor and carbon dioxide showed the same general characteristics in all enamels as did the gases alone except that the defects were not as pronounced.

(5) Graphite

The effect of the graphite film on the behavior of the castings was variable. In general, it accentuated the noticeable defects shown when it was not present. Thus, enamel B in a CO_2 atmosphere was much more spongy with graphite than without, and the black specking of enamel B in nitrogen was more pronounced with graphite than without.

The effect of the graphite on the physical properties was variable. Thus, with enamel A, graphite decreased adherence in all cases and decreased thermal resistance in air and carbon dioxide but increased it slightly in nitrogen. With enamel B, impact resistance was changed but slightly. The thermal resistance, however, was markedly decreased in air and considerably increased in CO_2 and nitrogen. Enamel C showed only slight

TABLE III

EFFECT OF GRAPHITE ON CAST-IRON ENAMELS

Gas added to furnace atmosphere (type)	(% added)	Impact and resistance (ft.-lb.)	Thermal resistance: Crazing temp. (°F)	Thermal resistance: Hairlining temp. (°F)	Surface appearance
			Enamel A		
Normal		1.12	176	238	Pinholed
CO_2	8	2.20	268	352	Very spongy
N_2	10	1.61	434	640	Pinholed
			Enamel B		
Normal		1.84	464	502	OK
CO_2	8	2.42	684	730	Some black specks
N_2	10	1.54	No failure at 1000°		Very bad black specks
			Enamel C		
Normal		1.52	310	354	No defects
CO_2	8	1.72	452	524	"
N_2	10	1.55	508	572	"

FIG. 5.—Spongy structure and pinholing caused by application of lead-bearing enamel over graphited cast iron (×12).

variation in adherence and the change in thermal resistance was not large. One of the most interesting phenomena exhibited by the graphited samples was the pinholing of enamel A (Fig. 5). Defects of this type are often encountered in lead enamels, and it is possible that graphite may provide the answer.

(6) Firing and Water Vapor

Enamel A was overfired and underfired 30°F in a 5% water-vapor atmosphere to determine the effects upon the visual defects. The overfired sample showed no blisters, but it exhibited a distinct loss of gloss; the underfired specimen showed no loss in gloss, but it blistered.

VI. Discussion of Results

The results of the present study would indicate that the gas conditions which may be expected to be found in faulty furnace atmospheres may affect different types of cast-iron enamels differently.

Thus, visually, the lead enamel (A) reacted to carbon dioxide and water vapor; the leadless enamel (B) reacted to all atmospheres to some extent; and the leadless enamel over ground coat (C–1) was not visibly affected. The physical properties of all the enamels were affected by the gases.

In some cases, the variation was due to the defects in the enamel as it was in the spongy structure of enamel A with CO_2 or the reaction of enamel B to water vapor and nitrogen. All three enamels showed highest test results in resistance to impact in the CO_2 atmosphere and lowest results in the water-vapor atmosphere. Reduction of oxygen content (except by water vapor) increased the adherence of enamel C. Enamels A and B showed decreased adherence with water vapor, nitrogen, and the water-vapor CO_2 mixture. All three enamels fired in abnormal atmospheres appeared to show increased thermal resistance.

There was some indication that the physical characteristics of the castings had considerable effect on the susceptibility of the various enamels toward defects. These data would indicate that water vapor is generally the most active cause of defects of all of the atmospheres studied and that the water vapor in flue gases present in leaky muffles may be far more deleterious than the carbon dioxide.

VII. Conclusions

(1) The behavior of the several types of cast-iron enamels fired in various types of atmosphere varies with the atmosphere.

(2) Water vapor gives rise to blisters in lead cast-iron enamels and to blisters, blackspecks, and pop-offs in leadless cast-iron enamels applied direct on the iron; it decreases the adherence of all three types of enamel.

(3) Carbon dioxide causes lead enamels to become spongy and leadless enamels direct on the iron to become slightly spongy.

(4) Oxygen deficiency causes serious black specking with leadless enamels applied direct on the iron but does not affect the other types seriously.

(5) Oxygen deficiency appears to improve slightly the adherence of leadless enamels applied over a ground coat.

(6) Mixtures of water vapor and carbon dioxide show characteristics of both gases but apparently not as violently.

(7) Water vapor seems to be more deleterious than the other gas conditions studied.

(8) Graphite causes pinholes of the type often encountered in lead cast-iron enamels and increases all tendencies toward defects.

(9) Leadless cast-iron enamels applied over a ground coat are affected less by furnace atmospheric conditions than other types of cast-iron enamels.

(10) The characteristics of the iron itself play a considerable part in the reaction of cast-iron enamels to abnormal furnace atmospheres.

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STUDY OF MILLING AND ITS EFFECT ON PROPERTIES OF PORCELAIN ENAMEL SLIPS*

BY R. L. FELLOWS AND J. L. MCLAUGHLIN

ABSTRACT

In studying the effect of some of the variables in ball-mill operation on porcelain enamel slips, variations in the amount of frit charge, amount of ball charge, size of balls, and r.p.m. of the mill were found to change the fineness distribution of a white steel enamel. Other variables, such as the water content, temperature of milling, and pressure under which the enamel was milled, apparently had little effect on the fineness of the enamel. An increase in temperature at which the enamels were milled decreased the Na_2O to B_2O_3 ratio of the mill liquor and decreased the set of the enamel. Variation in milling under the conditions stated had no effect on the opacity or gloss and texture of the enamels.

I. Introduction

From laboratory studies made previously by Lange and Fellows,[1] it was found that the fineness distribution curves for milled enamels could be determined by careful screen analysis down to 400-mesh. This work, as well as that of Poste,[2] indicated that there was a variation in fineness distribution of milled enamel slips owing to variations in mill practice. Accordingly, a systematic study of some of the variables in the operation of ball mills was made to determine the effect of variations in milling conditions on the fineness distribution, opacity, Na_2O to B_2O_3 ratio of mill liquor, etc.

II. Methods

(1) Milling of Enamels

A direct-drive mill, 24 by 36 inches, was used for most of the work; the inside dimensions were $18^3/_4$ by $31^1/_4$ inches and the mill ran at the recommended speed of 35 r.p.m. This size mill is often used in production and probably compares favorably with the operation of larger mills. A white steel frit was used in these tests and was milled with 7% Vallender clay and 2% tin oxide. No set-up agent was used. To minimize any variation in the materials used from mill to mill, sufficient frit, clay, and tin oxide were set aside for all of the mill tests. When the mills were loaded, an equal amount of frit was taken from each bag of frit set aside so that a uniform cross section of the frit was used in each mill. In running the mills, as many of the variables as possible were kept constant except the one being studied. To minimize any variation in water content when washing the mill, it was allowed to drain for 10 minutes before loading the next charge. Each mill of enamel was ground to 7 to 9% fineness on the 200-mesh sieve as measured by the standard method of the Enamel Division of The American Ceramic Society. The fineness and milling time were checked carefully.

(2) Fineness Distribution Tests

Sufficient slip to give 100 grams of dry enamel was weighed and washed carefully through a nest of 100-, 115-, 150-, 170-, 200-, 250-, 270-, 325-, and 400-mesh sieves. The enamel was washed through the sieves slowly and thoroughly, and after washing, the residues were dried and shaken on a Ro-Tap shaker for 15 minutes. The residue on each screen was then weighed and plotted.

(3) Na_2O to B_2O_3 Ratio of Mill Liquors

Shortly after the mill was emptied, each enamel was set at 1.82 specific gravity and a 50-cu. cm. sample of partially clear mill liquor was obtained by filtering the enamel through a Buechner funnel on a No. 42 Whatman filter paper under high vacuum. To secure as

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Enamel Division). Received March 29, 1938.

[1] L. A. Lange and R. L. Fellows, "Use of Water Elutriator in Addition to Screen Tests in Determining Fineness Distribution of Milled Enamel," *Jour. Amer. Ceram. Soc.*, **21** [9] 297–303 (1938).

[2] E. P. Poste, "Fineness Distribution of Vitreous Enamel as Affected by Variations in Grinding," *ibid.*, **18** [10] 303–305 (1935).

clear a sample of the mill liquor as possible, the entire sample was filtered again through a No. 42 Whatman filter paper without wetting the paper previously with water and without using suction.

Ten cubic centimeters of the clear mill liquor and 3 drops of 0.02% solution of methyl orange indicator were added to 90 cc. of distilled water, and the resulting solution was titrated with 0.05 *N* HCl to a p_H of 4.2 on a Beckman p_H meter. This p_H gives the characteristic pink color change for the methyl orange indicator end point. All of the alkalinity was calculated as Na_2O.

Another 10-cc. sample of the clear liquor was added to 90 cc. of distilled water and the number of cubic centimeters of 0.05 *N* HCl required for the Na_2O determination was added. The combined solution was boiled three minutes to remove the CO_2; after cooling, 3 drops of a 1% phenolphthalein solution was added, and the combined solution was titrated with 0.05 *N* NaOH to a p_H of 9 on a Beckman p_H meter in the presence of 1 gram of neutral mannite. Another gram of mannite was added to the solution to insure the complete ionization of all of the B_2O_3, and if there was no fading of the end point, the titration was considered to be complete; p_H 9 gives the characteristic pink end point for phenolphthalein indicator.

(4) Reflectance Tests

After adjusting the enamels to 1.82 specific gravity, reflectance plates were made, and the coefficients of scatter and reflectivity of the enamels were determined by the standard method of making reflectance tests.[3] From these values for coefficient of scatter and reflectivity, the weight-reflectance curves of the enamels were drawn.

(5) Pickup of Enamel

In order to obtain a comparison of the set of the enamels milled at various temperatures, the pickup of the enamel on a ground-coated, hollow steel cylinder was obtained. The cylinder was dipped in the enamels and slowly removed vertically from the enamel by a fine wire fastened across the diameter at one end, and the wet weight of the enamel adhering to the cylinder was determined. Each enamel was set at 1.82 specific gravity and aged for 24 hours, which allowed the enamels to come to room temperature before making the test.

(6) Temperature

The temperature of the enamel at the finish of milling was taken in each case. When the temperature at which the mill was started was varied from room temperature, the frit, mill additions, and water were allowed to come to the desired temperature, and the temperature was taken before starting the mill as well as at the finish of milling.

III. Variation in Milling

(1) Frit Charge

The mill was charged with 250 lb. of 2-inch balls, which was a little more than half full, and the frit charge was varied from 50 to 125 lb. in steps of 25 lb. The water addition to the mill was carefully weighed at 40% of the weight of the frit, and the proper proportion of clay and tin oxide was used. The proper charge for this mill is about 100 lb. of frit.

(2) Ball Charge

The following amounts of 2-inch balls were used to determine the effect of various amounts of balls on the fineness distribution, opacity, etc., of the enamel: 125, 187½, 250, 281¼, and 312½ lb. The mill charge was 100 lb. frit, 7 lb. clay, 2 lb. tin oxide, and 40 lb. water. The recommended amount of balls for this mill is 250 to 280 lb. A ball charge of 125 lb. is too small because about 25 hours are required to mill the enamel as compared to 3¾ hours when 250 lb. of balls are used.

(3) Ball Size

The mill was loaded with 1-, 1½-, 2-, and 3-inch balls, keeping the amount of ball charge at 250 lb. in each case. Because the bulk volume per 100 lb. of the various size balls is nearly the same, 250 lb. of any of the balls used filled the mill a little more than half full. The mill was charged with 100 lb. frit, 7 lb. clay, and 2 lb. tin oxide. In this series, 37½ lb. water were used rather than 40% as in the others. The enamels were again milled to a fineness of 7 to 9% on the 200-mesh sieve.

(4) Water Content

Keeping the frit charge at 100 lb. with the usual mill additions and using 250 lb. of 2-inch balls, the water content was varied between 30 and 45%.

(5) Pressure Under Which Enamels Were Milled

To determine whether the pressure that is built up in a mill during milling would have any effect on the properties of the enamel, mills were run with initial pressures as follows: 17 inches mercury vacuum atmospheric pressure, 2 lb. per sq. in. and 5 lb. per sq. in., respectively. The mill was charged with 250 lb. of 2-inch balls and loaded with 100 lb. frit, 7 lb. clay, 2 lb. tin oxide, and 40 lb. water.

(6) Temperature

The temperature at which the enamels were milled was varied from 88° to 138°F, and it was controlled by inclosing the mill in an insulated housing, equipped with a means of heating with a temperature control. The frit and mill additions (except the water) were placed in the mill and allowed to come to the desired temperature by standing overnight. The water addition of the same temperature was added, and the mill was started. The temperature on the outside of the mill was maintained at the starting temperature,

[3] Porcelain Enamel Institute, "Reflectance Test of Opaque White Porcelain Enamels," March, 1937. 612 North Michigan Ave., Chicago, Ill.

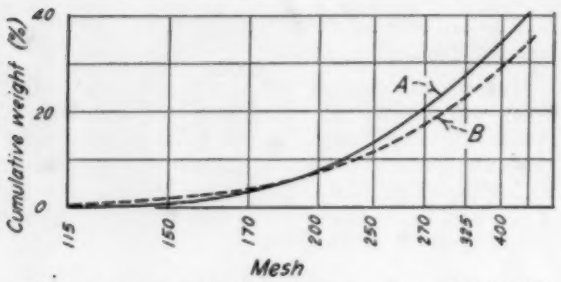

Fig. 1.—*B* = 50-lb. frit charge; *A* = 125-lb. frit charge.

	Cumulative weight (%)			
Mesh	50	75	100	125
100	0.2	0.2	0.1	0.0
115	0.6	0.6	0.5	0.2
150	2.2	2.1	2.1	1.6
170	4.0	3.7	4.0	3.3
200	7.8	7.4	8.3	8.3
250	11.8	12.3	13.2	13.8
270	17.4	18.2	19.8	20.4
325	22.9	24.0	26.3	27.5
400	29.6	31.1	33.1	34.7

though the enamel in the mill heated up about 10° to 20°F higher by the time it had milled to the necessary fineness. One mill was run with water trickling on the outside to cool the mill as much as possible while it was being run. The temperatures at the beginning and the end of milling are shown in Table I.

TABLE I

VARIATION IN TEMPERATURE OF MILLING

	Temp. °F	
	Beginning	Finish
Water-cooled	78.0	88.1
Room temperature	78.0	96.3
Heated	90.3	104.0
"	96.0	112.0
"	115.0	126.5
"	126.0	138.0

(7) Speed of Revolution of Mill

In studying the effect of r.p.m. on the milling, a mill was used that was slightly larger than that used in the previous work. This mill was belt-driven, and the r.p.m. was varied by changing the size of the pulley on the drive shaft. The inside dimensions of the mill were $21^1/_4$ by $32^1/_2$ inches and it was charged with 300 lb.

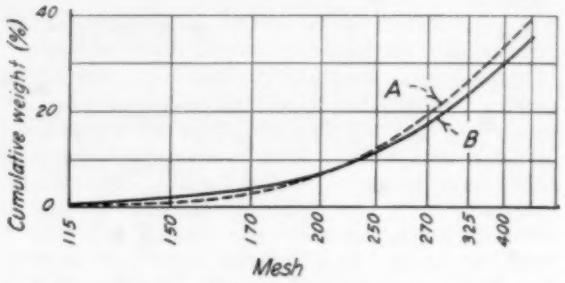

FIG. 2.—*A* = 125-lb. ball charge; *B* = $312^1/_2$-lb. ball charge.

	Cumulative weight (%)				
Mesh	125	$187^1/_2$	250	$281^1/_4$	$312^1/_2$
100	0.0	0.0	0.1	0.1	0.2
115	0.2	0.2	0.5	0.6	0.7
150	1.4	1.4	2.1	2.2	2.5
170	3.0	3.2	4.0	4.0	4.5
200	7.2	7.4	8.3	7.2	7.3
250	12.5	13.1	13.2	11.7	11.9
270	19.8	19.9	19.8	17.9	17.8
325	26.7	27.5	26.3	24.3	23.9
400	33.8	35.0	33.1	30.8	30.1

of 2-inch porcelain balls and 120 lb. of frit with 7% clay, 2% tin oxide, and 40% water. The usual recommended speed for the mill is 36 r.p.m., which is obtained with a 5-inch pulley. The size of the pulleys varied from 4 to 8 inches, which gave a range of r.p.m. from 30 to 57 and critical speeds from 50 to $94^1/_2$%. All of the enamels were milled to 7 to 9% residue on a 200-mesh sieve as before.

TABLE II

MILLING TIMES OF ENAMELS MILLED UNDER VARIOUS CONDITIONS

Variation in frit charge			Variation in ball charge			Variation in ball size			Variation in water content			Variation in speed of mill		
Frit charge (lb.) variables	Milling time (hr.)	(min.)	Ball charge (lb.)	Milling time (hr.)	(min.)	Ball size (in.)	Milling time (hr.)	(min.)	Water content (%)	Milling time (hr.)	(min.)	Mill speed (r.p.m.)	Milling time (hr.)	(min.)
50	1	50	125	25	45	1	2	40	30	4	50	30	4	40
75	2	35	$187^1/_2$	9	35	$1^1/_2$	3		$32^1/_2$	3	55	36	4	5
100	3	45	250	3	45	2	3	20	35	3	25	42	3	15
125	7	55	$281^1/_4$	3	40	3	4	15	$37^1/_2$	3	20	50	2	30
			$312^1/_2$	4	15				40	3	45	57	2	25
									45	4	40			
Frit. charge (lb.)				100			100			100			120	
Constants														
Ball charge (lb.)	250						250			250			300	
Ball size (in.)	2			2						2			2	
Water content (%)	40			40			$37^1/_2$						40	
Mill speed (r.p.m.)	35			35			35			35				
Mill size ($18^3/_4$ x $31^1/_4$ in.)				$18^3/_4$ x $31^1/_4$			$18^3/_4$ x $31^1/_4$			$18^3/_4$ x $31^1/_4$			$21^1/_4$ x $32^1/_2$	

IV. Results

(1) Milling Times

Table II shows the milling times of the enamels milled under various conditions. Variations in temperature and pressure at which the enamels were milled had little effect on the milling time.

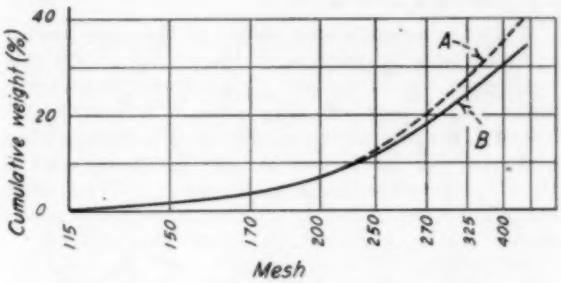

FIG. 3.—*A* = 1-in. balls; *B* = 3-in. balls.

	Cumulative weight (%)			
Mesh	1 in.	1½ in.	2 in.	3 in.
100	0.5	0.1	0.2	0.2
115	0.8	0.4	0.7	0.7
150	2.1	1.8	2.4	2.4
170	3.8	3.6	4.4	4.3
200	7.4	7.6	8.3	7.7
250	12.8	12.5	13.8	12.3
270	20.4	19.9	20.4	18.2
325	27.6	26.5	26.6	24.3
400	35.2	34.3	33.4	30.9

(2) Fineness Distribution

(*a*) *Variation in Frit Charge:* The effect of variation in frit charge on the fineness distribution of the milled enamel is shown in Fig. 1. Although the percentage residue on the 200-mesh sieve was practically identical for each enamel, the cumulative percentage residue retained on the 400-mesh sieve increased as the mill charge was increased from an undercharged mill to an overcharged mill. The curves also show that there was a larger amount of material retained on the 150-mesh sieve from the undercharged mill than from the overcharged mill. These results agree with the fineness distribution curves for variable frit charges of ground-coat enamels which were reported previously.[1]

(*b*) *Variation in Ball Charge:* Figure 2 shows that when the enamels were milled to the same fineness on a 200-mesh sieve undercharging a mill with balls produced a larger percentage of residue on the 400-mesh sieve than when the mill was correctly or overcharged with balls. In this case, a higher percentage of residue was retained on the 150-mesh sieve when the mill was overcharged with balls than when it was undercharged.

(*c*) *Variation in Ball Size:* When 1-inch balls were used, about 3½ to 4% of the larger particles of frit remained unground and were retained on a 40-mesh sieve; only a small percentage was not ground in all other cases. Even though the enamel that passed a 40-mesh sieve was ground to the same fineness on a 200-mesh sieve, there was a larger percentage residue retained on the 400-mesh screen when 1-inch balls were used than when 3-inch balls were used (Fig. 3).

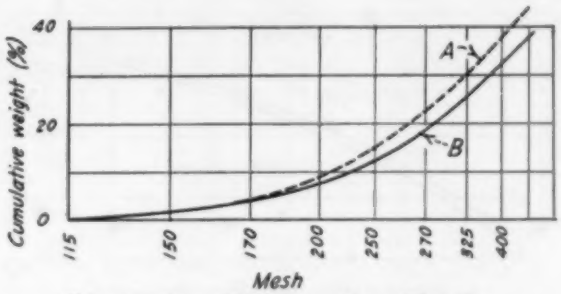

FIG. 4.—*A* = 30 r.p.m.; *B* = 57 r.p.m.

	Cumulative weight (%)				
Mesh	30	36	42	50	57
100	0.1	0.1	0.2	0.2	0.2
115	0.5	[illegible]	0.7	0.8	0.6
150	2.1	[illegible]	2.5	2.6	2.1
170	4.1	[illegible]	4.6	4.6	3.7
200	9.2	[illegible]	9.3	9.1	7.2
250	15.1	14.9	14.4	14.0	12.8
270	23.0	21.9	21.3	20.8	18.5
325	30.4	29.5	28.7	28.1	25.3
400	38.0	37.3	35.8	34.9	32.3

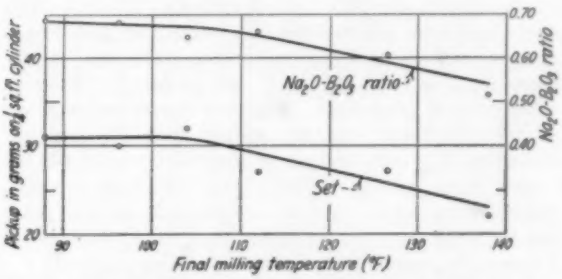

FIG. 5.—Relation of set and Na_2O to B_2O_3 ratio of mill liquors to temperatures at which enamels are milled.

(*d*) *Variation in Water Content, Pressure, and Temperature:* Variation in the water content, pressure, and temperature had little effect on the fineness distribution of the enamel within the range studied.

(*e*) *Variation in Speed of Revolution of Mill:* When the speed of the mill was varied from 30 to 57 r.p.m. and the enamels were milled to the same fineness on a 200-mesh sieve, it was found that the higher the r.p.m. of the mill the less the amount of residue retained on the 400-mesh sieve, although there was little difference on the 150-mesh sieve. These results are shown in Fig. 4.

(3) Na_2O to B_2O_3 Ratio and Set

There was no marked difference in the Na_2O to B_2O_3 ratio of the enamels owing to variations in mill practice except when the temperature was varied. In this case, an increase in the temperature of the milled enamel from 88° to 138°F decreased the Na_2O to B_2O_3 ratio from 0.68 to 0.51. The set of the enamel as determined by the amount of enamel picked up on a given sized cylinder decreased as the Na_2O to B_2O_3 ratio decreased. Figure 5 shows the relation between the set of the

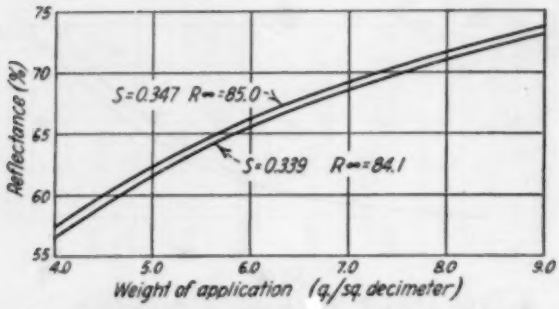

FIG. 6.—**Maximum difference in weight reflectance curves obtained with enamels milled under varying conditions.**

enamel and the Na_2O to B_2O_3 ratio for the enamel which was tested. The set of the enamels was tested again after aging one week and the same relation existed between the different mills, although the set of the enamels was less.

(4) Reflectance

In spite of the fact that there is a noticeable variation in the opacity of enamels when milled in different mills, there was little difference in the weight *vs.* reflectance curves, coefficient of scatter, or the reflectivity of the enamels ground in the same mill under the different conditions in these tests. Figure 6 shows the extremes of the reflectance curves obtained from the enamels milled in this test, and all of the other curves fell between these curves. The slight difference between these curves may be due to experimental error in making the reflectance plates rather than to any variable in the opacity caused by variation in milling practice.

(5) Temperature

There was little variation in the temperature due to milling under various conditions in this test. When the temperature at which the enamels were milled was varied, there was a marked effect on the Na_2O to B_2O_3 ratio of the mill liquor and the set of the enamels as previously discussed.

V. Conclusions

(1) Fineness Distribution

When the enamels were milled to the same residue as tested on a 200-mesh sieve, the residue on the 400-mesh sieve was as follows: (1) less when the mill was undercharged with frit than when overcharged; (2) less when the mill was overcharged with balls than when undercharged; (3) less when large balls were used in the mill than when small balls were used; (4) less when the mill was run at high r.p.m. than when run at slower speeds; (5) no variation with water content; (6) no variation with milling temperature; and (7) no variation with the pressure in mill.

(2) Set

An increase in the temperature at which this frit was milled decreased the Na_2O to B_2O_3 ratio of the mill liquor and the set of the enamels.

(3) Opacity

Variation in milling under the conditions stated had no effect on the opacity of the enamels.

(4) Appearance of Enamel

The gloss, texture, and general appearance of all of the enamels milled in these tests were satisfactory.

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EFFECT OF SOME ELECTROLYTES ON THE CONSISTENCY OF A DIPPING ENAMEL*

By R. J. Whitesell

Abstract

A comparison was made of the effect of various electrolytes on the consistency of a dipping enamel. The results indicated that the order of preference of the electrolytes tested was sodium nitrite, barium chloride, magnesium sulphate, potassium carbonate, and hydrochloric acid. The influence of the anion on the effect of various sodium compounds as electrolytes was determined.

I. Introduction

In a study to select the most suitable electrolyte for use with a white, triple-coat kitchenware enamel, successive additions of magnesium sulphate, barium chloride, sodium nitrite, potassium carbonate, and hydrochloric acid were made to the enamel slip, and the effect on the enamel consistency was determined with a consistometer. The stability of the consistency imparted by each electrolyte was determined by aging the enamel containing each electrolyte and again determining the consistency.

To determine the influence of various anions on the properties of the sodium ion as an electrolyte, the following sodium compounds were tested for effect on consistency: nitrite, nitrate, chloride, carbonate, sulfate, hydroxide, and silicate (also potassium carbonate).

II. Experimental

The test enamel was milled with 7% clay, 8% opacifier, and 40% distilled water to a fineness of 8 grams dry residue on a 200-mesh screen.[1] The specific gravity of the milled enamel was adjusted to 1.8, and the enamel was aged for 24 hours at 70°F.

The consistency of the enamel slip was determined with a consistometer, similar in general construction to that used by Harrison[2] and others. In detail, the consistometer was a straight glass tube, 1.22 cm. in diameter, calibrated in 10 milliliter units with a brass tube, 12 cm. long by 0.31 cm. internal diameter, adjusted so that its upper end was level with the 100-ml. graduation of the glass tube. A constant-temperature jacket was not used with the consistometer, inasmuch as all tests were made with the enamel and room temperatures at 70° ± 2°F. In operation, the tube was filled with enamel slip, and the time of flow for each 10 ml. was determined with two stop watches. The graph of the rate of flow *vs.* hydrostatic pressure is a straight line. By means of the angle of this line with the pressure axis (mobility) and its intersection with the pressure axis (yield point), the consistency of the enamel slip may be accurately defined.

All electrolytes were added as saturated solutions to prevent an appreciable change in the water content of the enamel slip.

In the first series of trials, involving the use of magnesium sulphate, barium chloride, sodium nitrite, potassium carbonate, and hydrochloric acid, the magnesium sulphate was tested first. This electrolyte was added in four equal increments, and the total addition resulted in the enamel having a satisfactory consistency for dipping. The consistency of the slip was determined after each electrolyte addition as shown in Fig. 1. The enamel slips, without electrolyte and with the highest electrolyte addition, were aged for twenty-four hours and the consistency was determined again. A similar procedure was followed for the other electrolytes, in each case attempting to have the highest electrolyte addition give the same yield point as the highest addition of magnesium sulphate.

Tests on the various sodium compounds were made in a similar manner. In these trials, however, the effect of aging was not determined. The frit used in the enamel for these trials was processed in a slightly different manner than that used for the enamel in the first trials.

III. Results

The results of the consistometer trials of the first series are shown graphically in Figs. 1 to 5, inclusive, from which the yield point and mobility data of Table I and Fig. 6 were taken. The results of the consistometer trials of the second series are shown graphically in Figs. 7 to 13, inclusive, from which the yield point and mobility data of Table II and Fig. 14 were taken.

In the graphs showing the consistometer data, the rate of flow in cubic centimeters per second is plotted against mean hydrostatic pressure in grams per square centimeter and shearing stress in dynes per square centimeter. For the particular instrument used, the shearing stress was 6.38 times the hydrostatic pressure. In the tables and graphs summarizing the results, the yield point is designated as the hydrostatic pressure of theoretical zero flow and the mobility is designated as the angle of the flow pressure curve with the pressure axis.

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* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Enamel Division). Received March 29, 1938; revised copy received March 16, 1939.

[1] Determined by the Standard Method of the Enamel Division of The American Ceramic Society.

[2] W. N. Harrison, "Controlling the Consistency of Enamel Slips," *Bur. Stand. Tech. Paper*, No. 356, pp. 96–98 (1927).

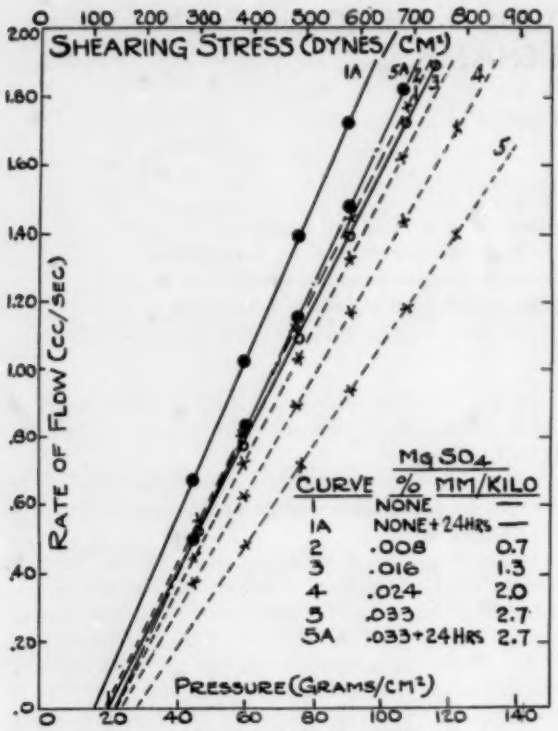

FIG. 1.—Series 1, $MgSO_4$ addition.

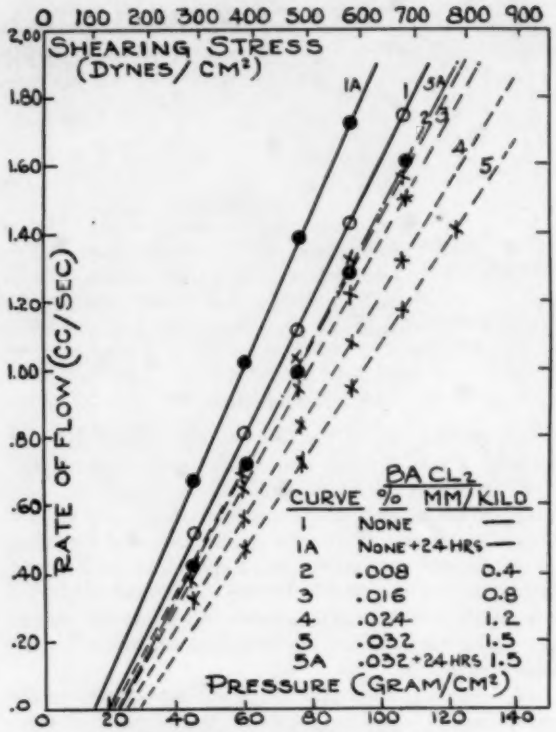

FIG. 2.—Series 1, $BaCl_2$ addition.

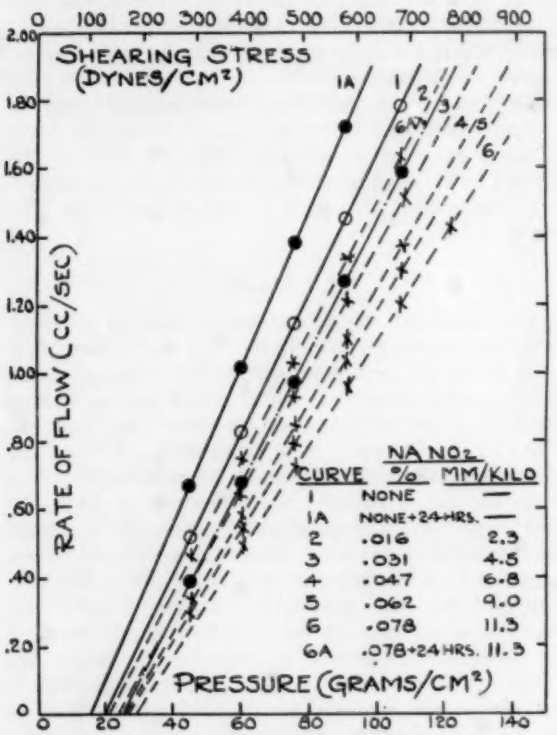

FIG. 3.—Series 1, $NaNO_2$ addition.

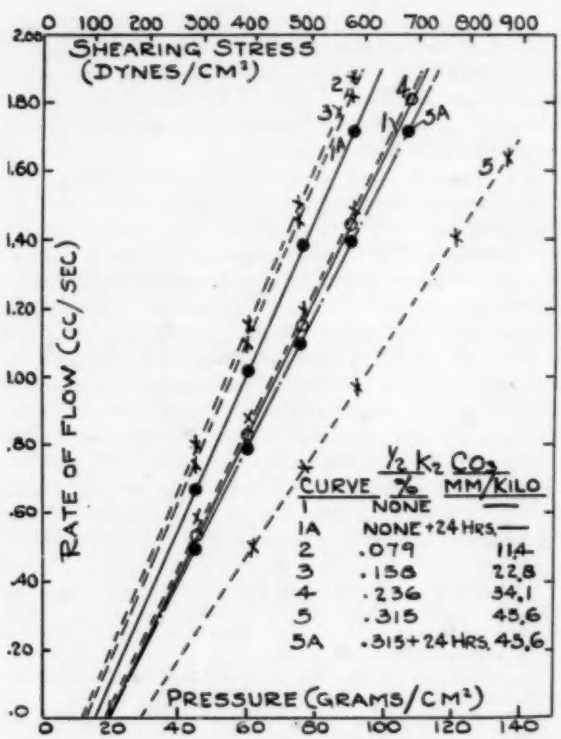

FIG. 4.—Series 1, K_2CO_3 addition.

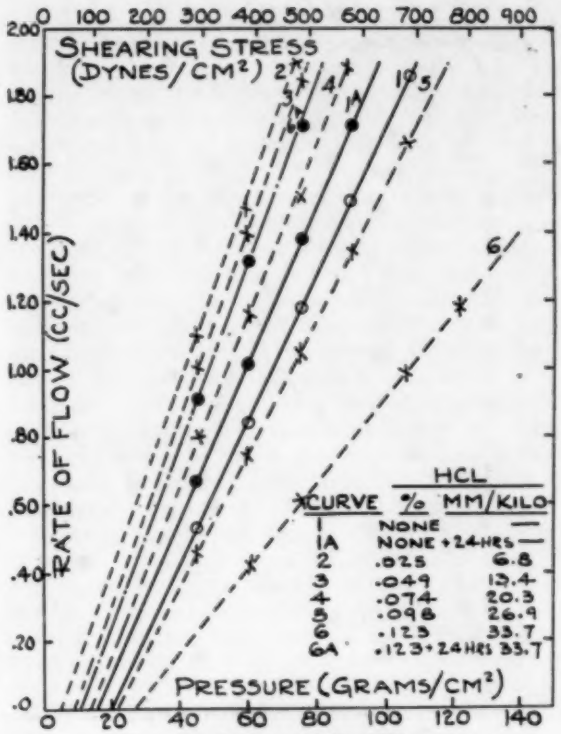

FIG. 5.—Series 1, HCl addition.

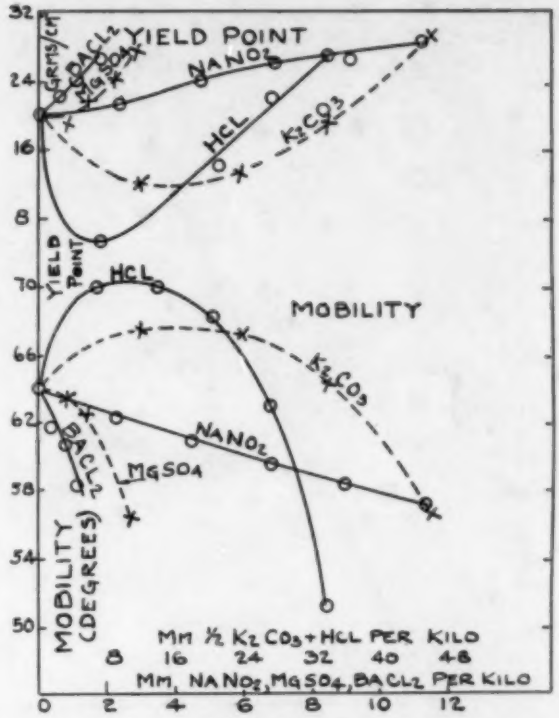

FIG. 6.—Series 1, effect of various electrolytes on mobility and yield point.

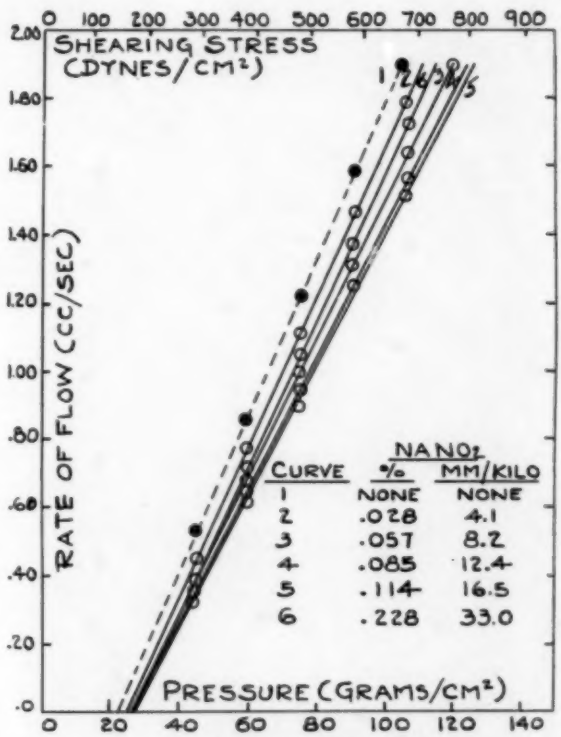

FIG. 7.—Series 2, $NaNO_2$ addition.

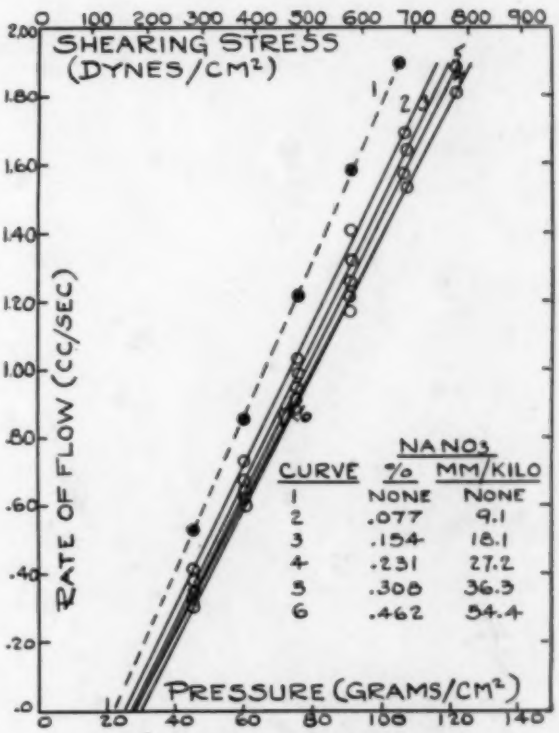

FIG. 8.—Series 2, $NaNO_3$ addition.

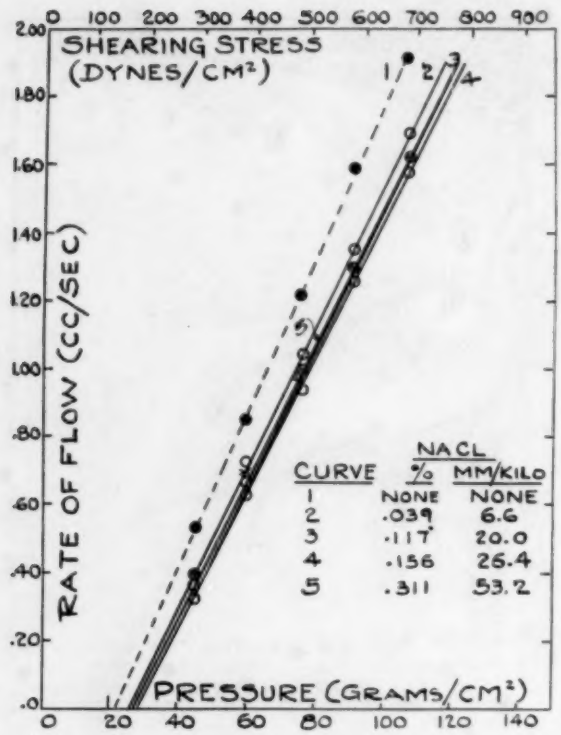
SHEARING STRESS (DYNES/CM²)
RATE OF FLOW (CC/SEC)
PRESSURE (GRAMS/CM²)
NACL
CURVE | % | MM/KILO
1 | NONE | NONE
2 | .039 | 6.6
3 | .117 | 20.0
4 | .156 | 26.4
5 | .311 | 53.2

FIG. 9.—Series 2, NaCl addition.

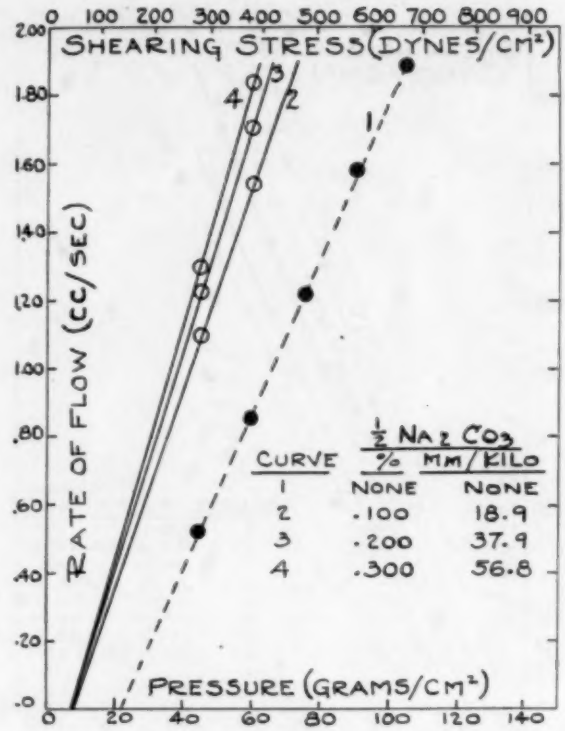
SHEARING STRESS (DYNES/CM²)
RATE OF FLOW (CC/SEC)
PRESSURE (GRAMS/CM²)
½ Na₂CO₃
CURVE | % | MM/KILO
1 | NONE | NONE
2 | .100 | 18.9
3 | .200 | 37.9
4 | .300 | 56.8

FIG. 10.—Series 2, Na_2CO_3 addition.

TABLE I

Electrolyte	Millimoles/kilo	%	Time after addition (hr.)	Mobility (degree)	Yield point	Aging change: Mobility (degree)	Aging change: Yield point
None				63.9	20		
"			24	66.6	16	+ 2.7	− 4
$MgSO_4$	0.7	0.008		63.4	19		
"	1.3	.016		62.5	22		
"	2.0	.024		60.0	24		
"	2.7	.033		56.2	29		
"	2.7	.033	24	64.9	22	+ 8.7	− 7
$BaCl_2$	0.4	.008		61.7	21		
"	0.8	.016		60.8	23		
"	1.2	.024		58.3	25		
"	1.5	.032		56.4	29		
"	1.5	.032	24	62.3	23	+ 5.9	− 6
$NaNO_3$	2.3	.016		62.3	21		
"	4.5	.031		61.0	24		
"	6.8	.047		59.4	26		
"	9.0	.062		58.3	27		
"	11.3	.078		57.0	29		
"	11.3	.078	24	62.6	25	+ 5.6	− 4
$^1/_2K_2CO_3$	11.4	.079		67.3	12		
"	22.8	.158		67.2	13		
"	34.1	.236		64.3	19		
"	45.6	.315		56.8	29		
"	45.6	.315	24	63.1	20	+ 6.3	− 9
HCl	6.8	.025		70.0	5		
"	13.4	.049		70.0	9		
"	20.3	.074		68.2	14		
"	26.9	.098		62.8	21		
"	33.7	.123		51.0	27		
"	33.7	.123	24	69.4	11	+18.4	−16

IV. Discussion of Results

In the comparison of magnesium sulphate, barium chloride, sodium nitrite, potassium hydroxide, and hydrochloric acid, it will be noticed that all except hydrochloric acid raised the yield point from 20 to 29 grams per sq. cm. with approximately the same decrease in mobility, *i.e.*, 7 to 8°. Hydrochloric acid, with a greater decrease in mobility, did not increase the yield point as much as the other four electrolytes.

The aging trials indicated the order of decreasing retention of yield point to be sodium nitrite, barium chloride, magnesium sulphate, potassium carbonate, and hydrochloric acid. Figure 6 shows that the electrolytes resulting in the most stable consistency are those which increase the yield point constantly with successive additions, *i.e.*, sodium nitrite and barium chloride; the electrolytes resulting in unstable consistency are those which first decrease the yield point and then increase the yield point with successive additions, *i.e.*, hydrochloric acid and potassium carbonate.

A comparison of the quantity of each electrolyte required to "set-up" the test enamel (Fig. 6) showed that the results in general were similar to those found in colloid studies, *i.e.*, the effectiveness of an electrolyte in the flocculation of a negatively charged sol is governed principally by the valence of the cation of that electrolyte.[3] Other trials of the writer with trivalent and tetravalent electrolytes, such as aluminum chloride and thorium nitrate, have also shown this to be true.

[3] H. R. Kruyt, Colloids, pp. 65–78. John Wiley & Sons, Inc., New York, 1927.

TABLE II

Electrolyte	Millimoles per kilo	(%)	Mobility (degree)	Yield point
None			66.3	22
$NaNO_2$	4.1	0.028	65.6	25
"	8.2	.057	63.4	26
"	12.4	.085	62.8	27
"	16.5	.114	62.5	27
"	33.0	.228	65.0	27
$NaNO_3$	9.1	.077	64.2	25
"	18.1	.154	63.9	27
"	27.2	.231	63.0	29
"	36.3	.308	63.4	28
"	54.4	.462	62.6	28
NaCl	6.6	.039	64.2	26
"	20.0	.117	63.9	28
"	26.4	.156	63.4	28
"	53.2	.311	63.4	27
$\frac{1}{2}Na_2CO_3$	18.9	.100	71.3	8
"	37.9	.200	72.8	7
"	56.8	.300	73.7	7
$\frac{1}{2}Na_2SO_4$	4.2	.030	69.0	18
"	8.4	.060	70.0	17
"	16.8	.119	70.8	14
"	33.5	.238	72.3	10
NaOH	14.3	.057	68.2	9
"	28.6	.114	67.4	10
"	42.9	.172	66.2	12
"	57.2	.229	65.1	16
"	71.5	.286	62.5	22
"	85.8	.343	56.5	30
"	100.2	.400	45.3	38
$\frac{1}{2}K_2CO_3$	20.5	.142	68.8	10
"	41.0	.283	67.5	17
"	61.5	.425	53.3	29

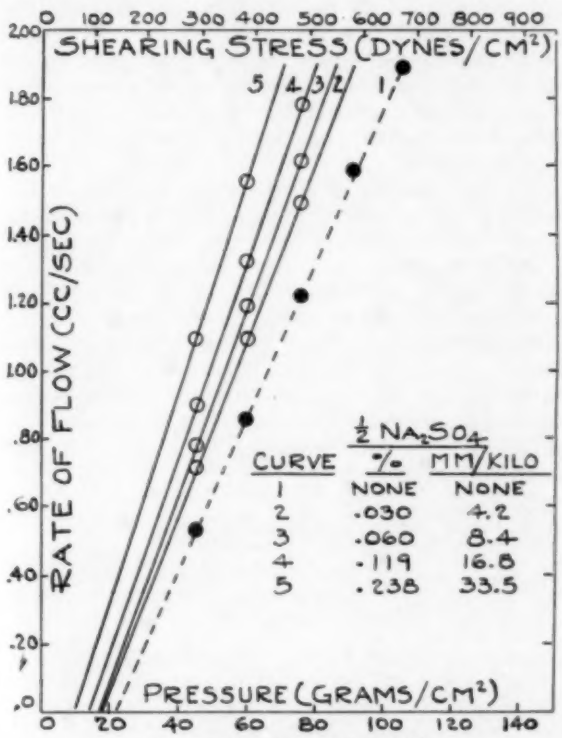
SHEARING STRESS (DYNES/CM²)
RATE OF FLOW (CC/SEC)
PRESSURE (GRAMS/CM²)
½ Na₂SO₄
CURVE | % | MM/KILO
1 | NONE | NONE
2 | .030 | 4.2
3 | .060 | 8.4
4 | .119 | 16.8
5 | .238 | 33.5

FIG. 11.—Series 2, Na_2SO_4 addition.

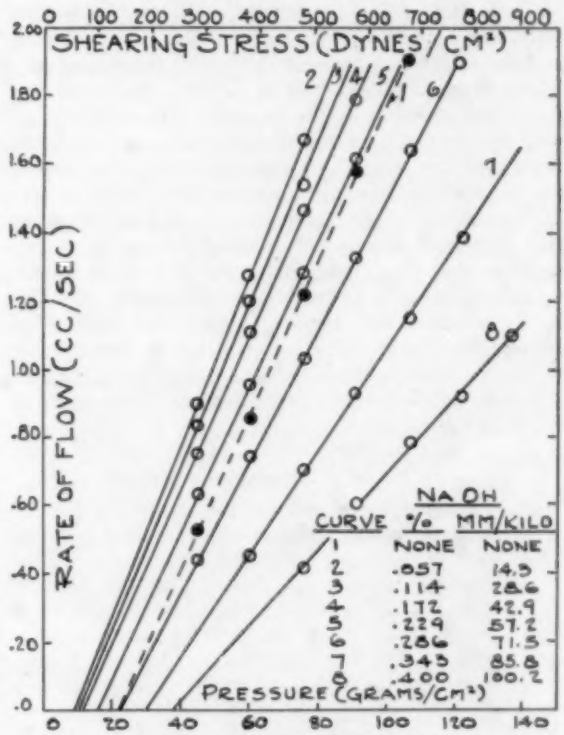
SHEARING STRESS (DYNES/CM²)
RATE OF FLOW (CC/SEC)
PRESSURE (GRAMS/CM²)
NA OH
CURVE | % | MM/KILO
1 | NONE | NONE
2 | .057 | 14.3
3 | .114 | 28.6
4 | .172 | 42.9
5 | .229 | 57.2
6 | .286 | 71.5
7 | .343 | 85.8
8 | .400 | 100.2

FIG. 12.—Series 2, NaOH addition.

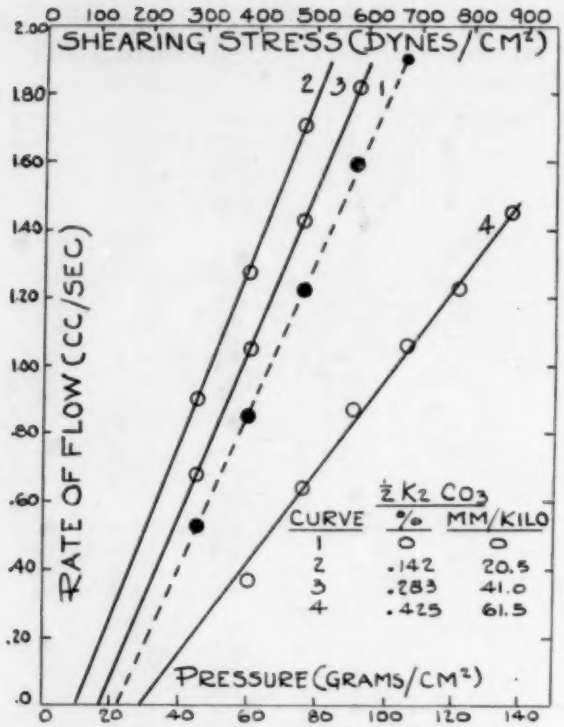

FIG. 13.—Series 2, K_2CO_3 addition.

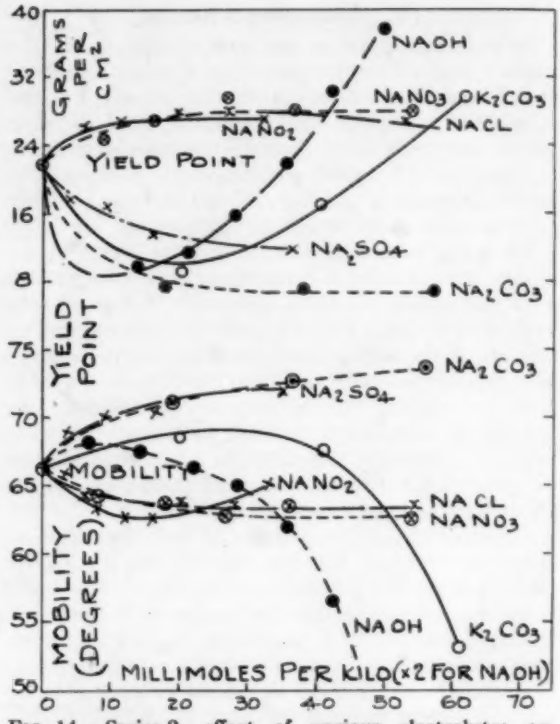

FIG. 14.—Series 2, effect of various electrolytes on mobility and yield point.

In the trials to determine the effect of the anion on the setting properties of the sodium cation, the results of Table II and Fig. 14 show that the neutral sodium salts with monovalent anions, *viz.*, the nitrite, nitrate, and chloride, had a beneficial action on the consistency. These salts, however, have a limited effect on yield point and mobility of the enamel. The sodium salts with bivalent anions, *viz.*, the sulphate and carbonate, decreased the yield point considerably. The carbonate was found to have a slight flocculating effect at very high additions The water introduced with this quantity of carbonate, however, reduced the specific gravity so much that the consistometer determinations were of no value. Sodium hydroxide and potassium carbonate first decreased and then increased the yield point beyond its original value. Even with very small additions, the sodium silicate (Na_2O–3.3 SiO_2–3.1 H_2O) resulted in settling, which made the consistometer determinations of no value.

V. Conclusions

(1) The common enamel electrolytes, *viz.*, sodium nitrite, barium chloride, magnesium sulphate, and potassium carbonate, will affect the consistency of an enamel to nearly the same degree; from the standpoint of the stability of the enamel consistency, however, the order of desirability is that given in these studies.

(2) Electrolytes which increase the yield point steadily with successive additions impart a more stable consistency to an enamel than those electrolytes which first decrease and then increase the yield point with successive additions.

(3) The quantity of an electrolyte required to impart a given consistency to an enamel is governed primarily by the valence of the cation of that electrolyte.

(4) With sodium electrolytes, the anion is important to the setting properties of the electrolyte. Neutral salts with monovalent anions have a small beneficial action on consistency, and those with bivalent anions have a detrimental effect on consistency. Basic salts of sodium (or potassium) which result in hydroxyl ion in solution give results similar to the hydroxide, first decreasing and then increasing the yield point with successive additions.

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THE CONDITIONS GOVERNING THE DIFFUSION OF WATER IN CLAYS*

By W. R. Morgan and R. K. Hursh

Abstract

Drying tests were made on Florida clay under various conditions of temperature, relative humidity, and thickness of the specimen and on packed grains of Indiana shale of various grain sizes and water contents. The results show the effects of these variables on the rate of drying and indicate that the rates of evaporation are less than would be expected for free liquid evaporation; that no initial constant rate of drying, as proposed by Sherwood and his associates, exists in the drying of clays; that the diffusion coefficient in the diffusion equation is not a constant, as assumed; and that the equation, as used by Sherwood, Newman, and others, is not applicable to the drying of clays. In general, the drying of clays may be said to take place in two stages, an initial stage during which the rate of drying decreases slowly and approximately linearly until shrinkage is completed at the surface, and a second stage during which the rate of drying falls off rapidly because of increased resistance to diffusion of liquid and vapor from the interior of the ware. The rather sharp discontinuity separating the two branches of the rate curve has been called the critical point or the surface shrinkage limit.

I. Introduction

(1) Diffusion and Drying

The determination of the mechanism of drying involves the relation between those forces which tend to produce evaporation and those which tend to restrain the movement of liquid or vapor through the body to the drying surface and into the drying air. In general, the force which tends to produce evaporation is the difference in the vapor pressure of the evaporating liquid and the partial pressure of its vapor in the drying air as determined by the temperature of the liquid and the temperature and humidity of the drying air. The forces resisting the removal of liquid are the resistances to diffusion of the liquid or vapor presented by the complicated and minute capillary system in the porous solid and by the stationary air films at the surface of the solid.

Considerable experimental work has been done on the effects of humidity, temperature, and air velocity on the evaporation of liquids from porous solids in the solution of drying problems. The study of the mechanism of drying in recent years has been approached both by the experimental method and by the development of mathematical theory, but the experimental verification of the theory unfortunately has lagged far behind the development of the mathematical theory.

The development of the latter theory has consisted almost entirely of the adaptation of Newton's law of diffusion to the diffusion of liquids and vapors through porous mediums. The law states that the rate of diffusion or the rate of change of the concentration is proportional to the rate of change of the concentration gradient and is expressed mathematically by the following equation:

$$\frac{\partial c}{\partial \theta} = K \frac{\partial^2 c}{\partial x^2}. \qquad (1)$$

c = concentration at any point.
x = distance from center of specimen to point in question.
θ = time.
K (proportionality factor) = diffusion constant.

The integration of the general differential equation has not been carried out for drying porous solids because of inadequate information concerning the so-called diffusion constant and the nature of the moisture gradient in the porous medium. In the development of the mathematical theory, the diffusion factor is assumed to be constant, and moisture is either uniformly distributed or the concentration gradient is linear or parabolic. Based on these assumptions, a great variety of mathematical manipulations has been carried out for the ordinary geometric shapes which might be encountered in the study of drying. A limited amount of experimental work has been carried out on such materials as wood, heelboard, paper pulp, and soap to test the application of the diffusion equation to the drying process, and a few isolated tests have been made on clay.

In general, when clay is mixed with increasing amounts of water, it gradually attains first a plastic consistency and then a sticky consistency, followed by the formation of a clay suspension known as a slip. Just before the clay becomes soft and sticky, each grain is surrounded by a film of water and the pores are filled with water.

When drying starts, the water moves from the interior to the surface, the water films surrounding the clay grains become thinner, the clay grains are drawn closer together by the surface tension of the water, and shrinkage occurs until finally the clay grains are in contact and shrinkage is completed. The volume of the water removed at this stage is equal to the shrinkage. Because water is removed more rapidly near the surface than from the interior, different degrees of

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 25, 1937 (General Session Symposium on Drying). Received July 22, 1938.

This paper is based upon data obtained by the senior author in preparation of a thesis which has been accepted by the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Ph.D.

shrinkage will exist from the surface to the center of the specimen, and stresses will be set up, owing to the tendency of the surface to shrink while the center portion is relatively incompressible. With further decrease in water content, a small residual shrinkage occurs, which is less than the volume of the water evaporated and is related to the colloidal material in the clay. A slight further shrinkage might also occur as stresses in the exterior portion are relieved by the drying of the interior. In the last stage of drying, no shrinkage takes place, but water continues to evaporate until equilibrium with the drying air is attained. At the end of the first stage, when the grains have just come into contact, further evaporation permits the entrance of air into the capillary system.

(2) Purpose of Study

The purpose of the present study has been to determine (1) the principles involved in the drying of clay bodies; (2) the effect of drying conditions as expressed by temperature and relative humidity on the moisture loss of the body and on the rate of drying; (3) the effect of particle size; (4) the effect of thickness of specimen or diffusion distance; and (5) the significance of the moisture distribution in the body at different stages of drying.

II. Experimental Procedure

(1) General Method

The decrease in weight was recorded as the moist specimen dried in a conditioned air stream flowing in the direction perpendicular to the single face of the specimen. Evaporation from other surfaces was prevented by a protective rubber coating. The original data were in the form of cumulative loss of weight at increasing lengths of time after the start of drying. Rates of evaporation were determined by measuring the slope of the loss-time curves and by numerical calculations from the interval losses.

(2) Preparation of Plastic Clay Specimens

Specimens were prepared from Florida kaolin, Tennessee ball clay, and a shale from Streator, Ill. These were selected because of differences in plasticity, shrinkage, and grain size. In the present paper, only data for Florida kaolin are presented.

The specimens were prepared by grinding to pass a 20-mesh sieve, tempering with 40% water, and extruding through a 1-inch diameter die.

The extruded column was cut into lengths slightly in excess of the desired final length, and each specimen was covered with a rubber casing by expanding a rubber toy balloon inside a glass tube under reduced pressure and inserting the specimen. The specimen was trimmed off even with the top of the casing, weighed immediately, and placed in the drier in the conditioned air stream.

(3) Preparation of Packed Specimens

Specimens were prepared from 8- to 14-mesh and −100-mesh Indiana shale by mixing with 7, 12, 19, and 25% water, on the basis of the dry weight of the clay, and by tamping into expanded rubber casings. A thin, split cardboard tube was inserted between the casing and the glass tube to facilitate the removal of the specimen, and the top of the casing was turned back over a narrow cardboard ring to prevent constriction of the specimen at the top.

(4) Experimental Measurements

Loss of weight during drying was measured directly by suspending the specimen from the arm of a balance by a wire passing through the top of the drier on which the balance rested. Measurements were made with an accuracy of 0.05 gram.

Equilibrium and total initial moisture concentrations were determined by drying uncoated control specimens to equilibrium weight in the conditioned air stream and then at 230°F in an electric oven. The average moisture concentrations of the rubber-coated specimens, which were weighed at intervals throughout the test, were calculated from the difference between the actual weight at a given time and the equilibrium or the dry weight as calculated from data on the control specimens.

Moisture concentration gradients were determined by removing coated specimens from the drier and by measuring the moisture content of segments of the specimen cut by a multiple saw. The segments were placed in weighing bottles to prevent loss of moisture, and after weighing they were dried at 230°F and weighed again. The moisture content of the various segments plotted against the distance from the drying face indicated the variation in moisture concentration from the drying face to the opposite end of the specimen.

Drying rates were calculated from the interval losses obtained from the original data and were also determined graphically by measurement of the slope of the cumulative loss curves, which were plotted from the original data. All drying rates were expressed in grams per hour. They were not reduced to rates per unit area of evaporation surface because of the uncertainty concerning the point at which the shrinkage of the surface of the specimens was complete. The arbitrary use of shrinkage to determine the area of the drying surface without accurate information concerning the stage of drying to which it applied would have been undesirable.

To determine the relation between actual moisture concentration, shrinkage, and the point at which the surface pores just began to be evacuated, measurements were made on groups of specimens dried slowly under atmospheric conditions. Under such conditions, the moisture concentration would be expected to be fairly uniform throughout the specimen so that average moisture concentrations would also represent the concentration at the surface of the specimen. At regular intervals during drying, specimens were placed in kerosene to stop drying, and the shrinkage and the volume of the pores from which water had been removed by drying were determined.

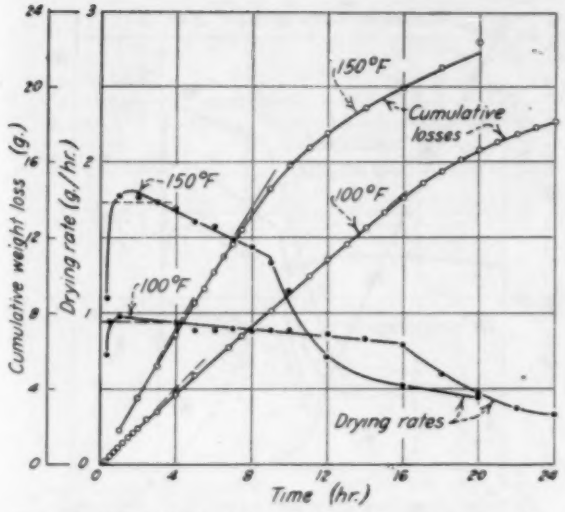

FIG. 1.—Typical time-loss and drying-rate curves for Florida kaolin (relative humidity constant at 40%).

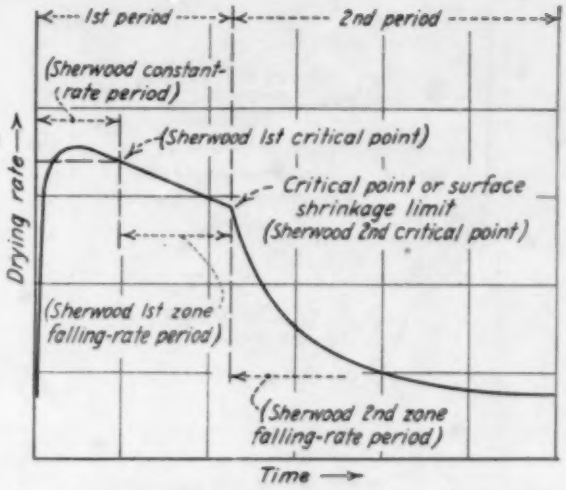

FIG. 2.—Comparison of stages of drying with those proposed by Sherwood.

Temperatures of the specimens during the various drying experiments were determined by observing a mercury thermometer inserted in the end opposite the drying face and along the axis to the center of the specimen.

(5) Scope of Tests

The effect on the drying procedure was determined for relative humidities of 20, 40, 50, and 60% with a constant temperature of 150°F and for temperatures of 100°, 123°, 150°, and 170°F with a constant relative humidity of 40%.

The effect of the thickness of the specimen was determined by drying specimens, varying in length from $^5/_{16}$ to 6 inches, at a constant dry-bulb temperature of 150°F and a relative humidity of 40%.

The effects of fineness of grain and initial water content were determined by drying tests on 8- to 14-mesh and −100-mesh Indiana shale mixed with 7, 12, 19, and 25% water on the basis of the dry weight of the clay. The tests were made at a dry-bulb temperature of 150°F and 40% relative humidity.

The effect of the initial temperature of the specimen on the drying characteristics was determined by preheating the specimens in sealed containers to prevent evaporation. The preheated specimens were then placed in the drier and were tested in the usual manner at 150°F and 40% relative humidity.

III. Results

(1) Presentation of Original Data

The specimens placed in the drying cabinet increased in weight during the first few minutes when the temperature was lower than the saturation temperature of the conditioned air stream. Usually within 15 minutes, the specimen had regained its initial weight.

During the early stages of drying, the relation between the elapsed time and the cumulative loss of weight of the specimen was well represented by a smooth curve of slight curvature. The relationship has usually been considered to be linear, as indicated by the tangents shown in Fig. 1. The solid-line tangents indicate the apparent point of tangency in the small-scale figures, and the broken-line tangents indicate the apparent point of tangency as determined on larger drawings in which the scales correspond to the accuracy of the original data.

With continued drying, the loss of weight per unit time decreased, producing a greater curvature in the time-loss curve, followed by a flattening of the curve as the loss of weight of the specimen approached its maximum.

(2) Drying Rates at Start of Drying

The actual values of the rates show a rapid initial increase during the heating-up period, followed by an approximately linear decrease to the point of discontinuity.

The temperature of the specimen and the rate of evaporation increased rapidly at first to maximum values. As the maximum was approached, the rate of evaporation leveled off and became a slowly decreasing rate which continued to the critical point. (This corresponds to Sherwood's second critical point.[1])

This conception of the drying-rate curve in the early stages of drying differs from that proposed by Sherwood[1] and others. A comparison of Sherwood's stages of drying with those proposed as a result of the present study is shown in Fig. 2.

(3) Effect of Initial Temperature of Specimen

The drying of the specimens was markedly affected during the first hour or more by their initial tempera-

[1] T. K. Sherwood, "Drying of Solids, I–II," *Ind. Eng. Chem.*, **21** [1] 12–16; [10] 976–80 (1929); III, **22** [2] 132–36 (1930); *Ceram. Abs.*, **9** [2] 134; [5] 385; [7] 588 (1930).

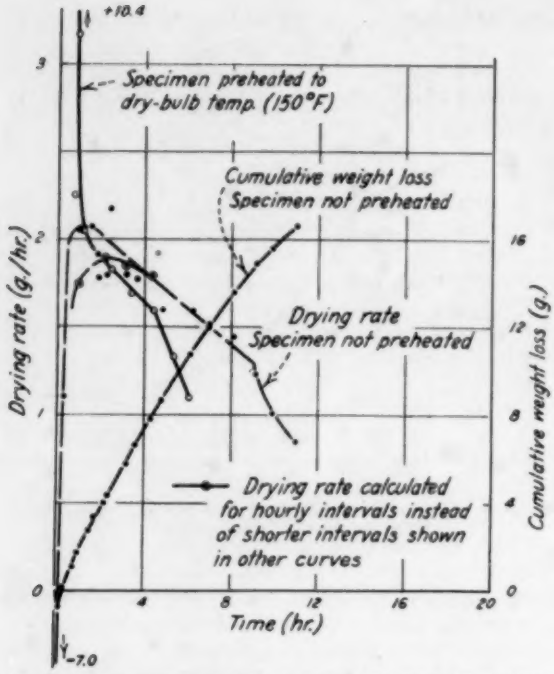
+10.4
Specimen preheated to dry-bulb temp. (150°F)
Cumulative weight loss Specimen not preheated
Drying rate Specimen not preheated
Drying rate calculated for hourly intervals instead of shorter intervals shown in other curves
Drying rate (g./hr.)
Cumulative weight loss (g.)
Time (hr.)
-7.0

FIG. 3.—Character of drying curves at start of drying.

ture. This is shown in Fig. 3 in which the drying rate of a specimen preheated to the dry bulb temperature before being exposed to drying conditions is compared with that of the unheated specimen.

(4) Volume Shrinkage and Unsaturated Pore Volume[2]

The volume shrinkage, volume of unsaturated pores, and average total moisture concentration were determined for Florida kaolin by drying specimens slowly at atmospheric temperature to keep the moisture gradient as small as possible. The results are shown in Figs. 4 and 5 and indicate that the appearance of unsaturated pores coincided approximately with the end of shrinkage, at which point the average moisture concentration was of the order of 0.24 gram per gram of dry clay.

In all cases of drying under various temperature and humidity conditions, the moisture concentration at the end of the so-called constant rate period was of the order of 0.30 to 0.35 gram per gram of dry clay. The average moisture content at that point thus had

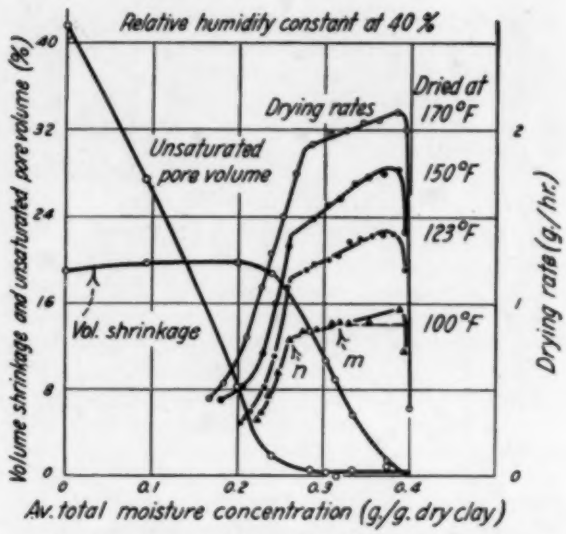

FIG. 4.—Relation between drying rates, volume shrinkage, volume of unsaturated pores, and average total moisture concentration for Florida kaolin dried at different temperatures.

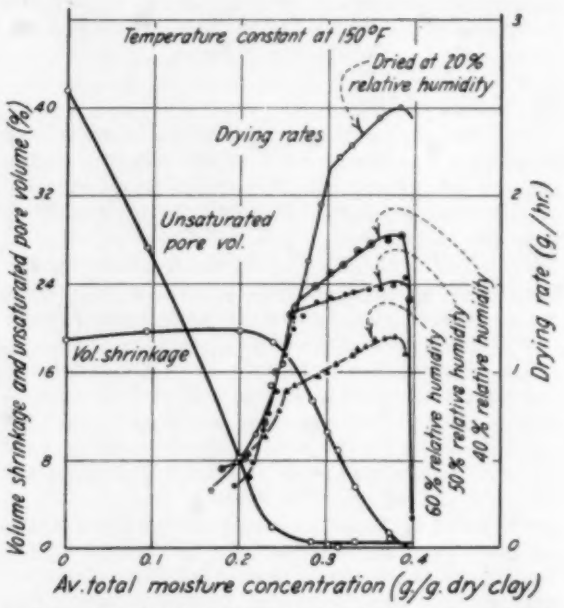
Temperature constant at 150°F
Dried at 20% relative humidity
Drying rates
Unsaturated pore vol.
Vol. shrinkage
60 % relative humidity
50 % relative humidity
40 % relative humidity
Volume shrinkage and unsaturated pore volume (%)
Drying rate (g./hr.)
Av. total moisture concentration (g./g. dry clay)

FIG. 5.—Relation between drying rates, volume shrinkage, volume of unsaturated pores, and average total moisture concentration for Florida kaolin dried at different humidities.

[2] References cited by the author on this part of the investigation are as follows:

(*a*) A. V. Bleininger, "Effect of Preliminary Heat Treatment upon Clays," *Trans. Amer. Ceram. Soc.*, **11**, 392–406 (1909).

(*b*) B. A. Keen, Physical Properties of the Soil. Longmans, Green, and Co., New York, 1931; *Ceram. Abs.*, **10** [8] 608 (1931).

(*c*) J. W. Mellor, "Notes on Shrinkage of Clays During Drying," *Trans. Ceram. Soc.* [England], **32** [10] 455–71 (1933); *Ceram. Abs.*, **13** [3] 71 (1934).

(*d*) H. H. Macey, "Principles Underlying the Drying of Clay," *Trans. Ceram. Soc.* [England], **33** [3] 92–103 (1934); *Ceram. Abs.*, **13** [8] 224 (1934).

no significant relationship to the completion of the shrinkage of the clay.

The moisture concentration at the critical point, however, corresponded closely to the moisture concentration at the end of shrinkage and tended to decrease as the severity of drying conditions decreased. It seems probable, therefore, that drying slowly under equilibrium conditions would reduce the moisture concentra-

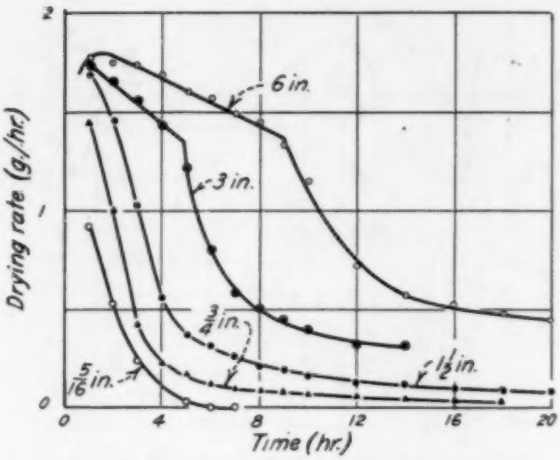

FIG. 6.—Effect of thickness of specimen on drying rate of Florida kaolin dried at 150°F and 40% relative humidity.

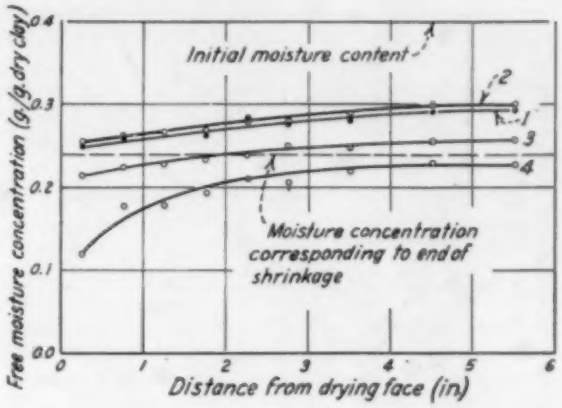
Free moisture concentration (g./g. dry clay)
Distance from drying face (in.)
Initial moisture content
Moisture concentration corresponding to end of shrinkage

FIG. 7.—Moisture concentration gradients in Florida kaolin.

	Temp. (°F)	Cut after	Critical point (hr.)
Dried at	(1) 123	10 hr.	12
	(2) 150	7 "	9
	(3) 100	17 "	16
	(4) 170	10 "	6.5

tion gradient to zero and that the average moisture concentration at the critical point would be equal to the concentration at the end of shrinkage. The moisture gradient in the specimen always causes the average moisture concentration at the critical point, under rapid drying conditions, to be higher than that required to fill the pores at the end of shrinkage.

(5) Effect of Temperature and Humidity (Initial Period)

The effect of increased temperature or decreased humidity was to increase the drying rate in the early stages of the process, whether the increase in partial pressure difference was caused by change in temperature or relative humidity. The increase in drying rate, however, was different for each type of clay and was greater for partial pressure differences produced by change in relative humidity than for equal differences produced by change in temperature.

(6) Effect of Temperature and Relative Humidity (Second Period)

For equal average moisture concentrations, the region of saturated pores and maximum vapor pressure will be farther from the surface in the specimen dried at the higher temperature and the resistance to diffusion of the vapor to the surface will be greater because of the increased length of path. The rate of drying in the second period following the critical point may therefore be expected to be higher for the specimen dried at the higher temperature until the effect of increased vapor pressure is counteracted by the increased resistance to diffusion and the combined effects of vapor pressure and resistance to diffusion are the same in the two specimens. At this point, the rates of drying should be equal, and beyond this point, the specimen dried at the lower temperature should dry more rapidly. At constant temperature, the gradient will be sharper for the specimen dried more rapidly at the lower humidity. This effect may be observed in Figs. 4 and 5.

These general results agree with those obtained by Carrier[3] and by Sherwood and Comings,[4(a)] according to which the rate of drying in the later stages was increased more by increased temperature than by decreased relative humidity.

(7) Effect of Thickness of Specimen

The effect of increased thickness of the specimen was to increase the length of the initial period during which the drying took place at a slowly decreasing rate as shown in Fig. 6.

The drying rates after equal lengths of time were higher for the thicker specimens because of the higher moisture concentrations in these specimens. On the basis of equal moisture concentrations, the critical point, if it appeared at all, occurred at higher average moisture concentrations in the thicker specimens. As the drying passed into the second zone of the falling-rate period, however, the thicker specimens dried at slower rates than did the thinner ones. This is consistent with the explanation already given.

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[3] (*a*) W. H. Carrier, "Rational Psychrometric Formulae," *Jour. Amer. Soc. Mech. Engrs.*, **33**, 1304 (1911); (*b*) "Temperature of Evaporation," *Jour. Amer. Soc. Heating and Ventilating Engrs.*, **24**, 25 (1918); (*c*) "Theory of Atmospheric Evaporation," *Ind. Eng. Chem.*, **13**, 432 (1921).

[4] (*a*) T. K. Sherwood and E. W. Comings, "Mechanism of Drying of Clays," *Ind. Eng. Chem.*, **25**, 311 (1933).

(*b*) T. K. Sherwood, "Drying of Solids; Application of Diffusion Equations," *ibid.*, **24** [3] 307–10 (1932); *Ceram. Abs.*, **11** [10] 541 (1932).

(*c*) E. R. Gilliland and T. K. Sherwood, "Drying of Solids; Diffusion Equations for Period of Constant Drying Rate," *Ind. Eng. Chem.*, **25** [10] 1134–36 (1933); *Ceram. Abs.*, **12** [12] 435 (1933).

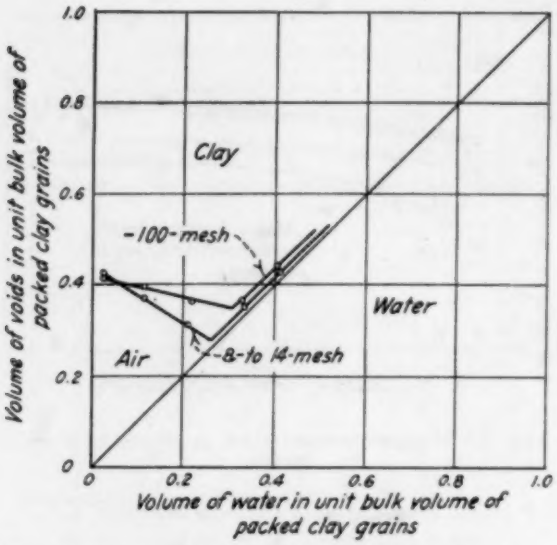
Volume of voids in unit bulk volume of packed clay grains
Clay
-100-mesh
Water
Air
8-to 14-mesh
Volume of water in unit bulk volume of packed clay grains

FIG. 8.—Relation between volume of voids and volume of water added in packed clay grains.

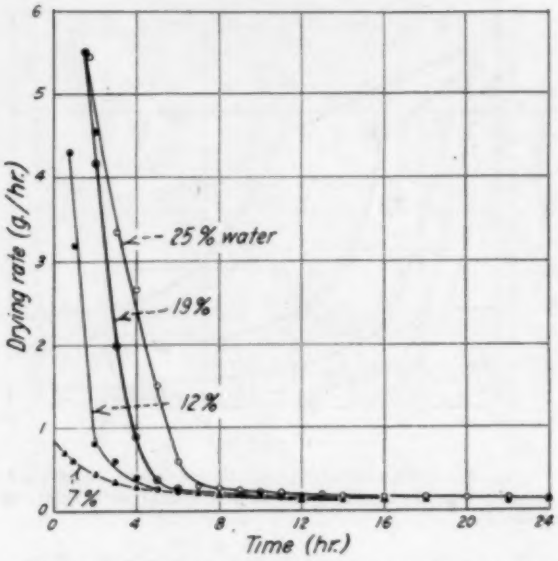

FIG. 9.—Effect of initial moisture content on drying rate of 8- to 14-mesh Indiana shale dried at 150°F and 40% relative humidity.

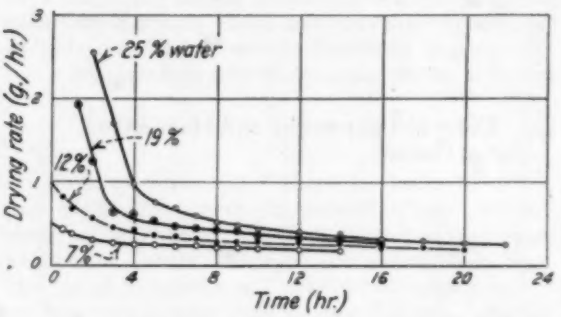

FIG. 10.—Effect of initial moisture content on drying rate of −100-mesh Indiana shale dried at 150°F and 40% relative humidity.

(8) Moisture-Concentration Gradients

In all cases, the concentration at the end of the specimen farthest from the drying face was less than the initial concentration, indicating that moisture diffusion was comparatively rapid and that the movement took place throughout the length of the specimen. The curves show no sharp change in gradient but a gradually decreasing rate of diffusion with increasing distances from the exposed face of the specimen. Typical curves for moisture-concentration gradients are shown in Fig. 7.

The initial slowly decreasing rate of drying is maintained as long as liquid continues to be supplied to the surface and shrinkage is not completed. As soon as shrinkage at the surface is complete, which occurs at the critical point, the liquid surface retreats into the solid; the resistance to diffusion increases, the rate of drying decreases rapidly, and the moisture gradients are much sharper.

The solid presumably is in equilibrium with the vapor in the pores rather than with the surrounding air. This accounts for the vapor-pressure difference at the surface and a driving force for the continuation of drying which could not exist with the surface concentration at the equilibrium value. This general conception of the concentration at the surface agrees with that assumed by Lewis,[5] by McCready and McCabe,[6] and by Newman,[7] but it shows Sherwood's[1] assumption of equilibrium concentration at the surface to be invalid.

(9) Effects of Grain Size and Initial Moisture Concentration

Because resistance to diffusion is believed to be some function of the capillary system and pore size in the clay mass and therefore of the grain size, increase in grain size should have a marked effect on drying rates. Furthermore, because increased length of specimen has been shown to increase the available supply of moisture, increase in initial moisture content in a given material would be expected to affect the length of the initial drying period.

Preliminary packing experiments were made to determine the water content which gave maximum density, inasmuch as water in excess of this amount would be expected to diffuse easily within the body, would more closely approach the conditions of free liquid evaporation, and should give high drying rates. The

[5] W. K. Lewis, "Rate of Drying of Solids," *Ind. Eng. Chem.*, **13**, 427 (1921).

[6] D. W. McCready and W. L. McCabe, "Adiabatic Air Drying of Hygroscopic Solids," *Trans. Amer. Inst. Chem. Engrs.*, **29**, 131–61 (1933); *Ceram. Abs.*, **14** [8] 194 (1935).

[7] (*a*) A. B. Newman, "Drying of Porous Solids; Diffusion Calculations," *Trans. Amer. Inst. Chem. Engrs.*, **27**, 310 (1931); (*b*) "Drying of Porous Solids; Diffusion and Surface Emission Equations," *ibid.*, p. 203.

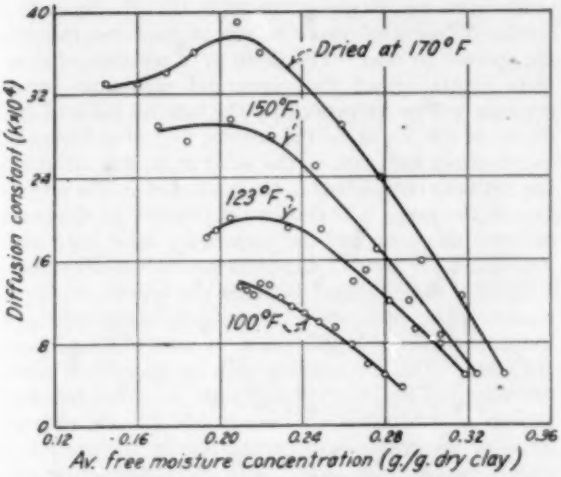

FIG. 11.—Relation between the diffusion constant, K, and moisture concentration of specimen under different drying conditions.

results of the packing tests are shown in Fig. 8. With increasing additions of water, the volume of the voids decreases to a point of maximum density and then increases with higher water content. As would be expected, the finer grains required more water to produce maximum density than the coarser grains. In the drying tests, the moisture content of the packed specimens included values both higher and lower than those required to produce maximum density.

The effect of increasing coarseness of grain, as shown in the drying-rate curves of Figs. 9 and 10, was to produce exceptionally high drying rates at the start of drying.

Increase in the initial water concentration caused an increase in the length of the initial period because of the increase in the available supply of moisture. The increased water concentration also caused the decrease in rate of drying to be somewhat less abrupt because, with the increased initial concentration, the zone of complete saturation would be nearer the surface and the resistance to diffusion would be less than in the case of specimens with lower initial moisture concentration.

(10) Free Liquid Evaporation

The actual rate of evaporation for the normal clays was of the order of 1.9 grams per hour, which was less than half the rate of free liquid evaporation (as calculated from the equations of Carrier,[3] Hinchley and Himus,[8] and Lurie and Michailoff [9]), the calculated rates ranging from 4.8 to 5.9 grams per hour.

In the tests on packed coarse grains of shale, the maximum rate of evaporation was of the same order of magnitude as the calculated rates of free liquid evaporation. This seems to indicate that free liquid evaporation does not occur in the early stages of drying of clays except possibly in extremely coarse materials.

The results then offer further evidence that an initial constant rate period of free liquid evaporation, proposed by Sherwood[1] and his associates,[4] does not exist in the drying of clays.

(11) Constancy of Diffusion Coefficient

The values of the diffusion coefficient, K, were calculated from the experimental data which were obtained under various drying conditions (Fig. 11). In all cases, for any given set of drying conditions, the value of K increased rapidly with decreasing moisture concentration of the specimen. For any given moisture concentration, the value of K also increased rapidly with increasing severity of the drying conditions.

The results obtained are directly opposed to the assumption that K is constant, which was made by Sherwood[1] and Newman[7] in the development of the mathematical theory and the integration of the differential equation for diffusion. A more logical proposal was made by Libman,[10] who developed a differential equation based on diffusion but who used a "flow function" expressed as a function of the moisture concentration.

Before the diffusion equation may be applied to the drying of clays, the proportionality factor or diffusion coefficient, K, must be determined as a function of the pore structure, moisture concentration, and concentration gradient.

(12) Mechanism of Drying

On the basis of drying rates, the drying process may be divided into two periods. Immediately after the start of drying, except for the initial effect of increasing temperature of the specimen, the drying rate slowly decreases as a result of the reduction of drying surface because of shrinkage and as a result of increase in resistance to diffusion because of reduction of the size of the pores, which is also associated with shrinkage. This initial period continues until shrinkage of the surface layers has been completed at "the surface shrinkage limit." During the initial period, evaporation occurs at the surface of the specimen, the supply of liquid being maintained by diffusion of liquid from the interior of the solid. At the "surface shrinkage limit," the concentration of the moisture in the surface layer is the concentration required to fill the pores with the grains in contact, which is the condition associated with the completion of shrinkage. Any further evaporation will cause the zone of complete saturation of the pores to recede and evaporation to take place within the solid. The diffusion to the surface now involves vapor diffusion as well as liquid diffusion. Because of the greater resistance to diffusion of vapor from beneath the surface than the previous resistance to diffusion of liquid to the surface, the rate of drying falls off rapidly after the surface shrinkage limit or critical point is reached. Shrinkage will not have been com-

[8] J. W. Hinchley and G. W. Himus, "Evaporation in Currents of Air," *Trans. Inst. Chem. Engrs.* [London], **2**, 57 (1924).

[9] M. Lurie and N. Michailoff, "Evaporation from Free Water Surface." Drying Laboratory of Theoretical Institute, Moscow, U.S.S.R. (unpublished).

[10] E. E. Libman, "Theory of Porous Flow," *Phil. Mag.*, **4** [7] 1285–90 (1927); *Ceram. Abs.*, **7** [5] 321 (1928).

pleted throughout the specimen at the surface shrinkage limit unless the rate of drying is so slow that no gradient exists and the average concentration of moisture is identical with the surface concentration. In general, however, a gradient will exist, and liquid will continue to diffuse from the sections in which shrinkage has not been completed. This liquid diffusion will tend to maintain the supply of liquid in the zone of evaporation. This zone will retreat from the surface only as shrinkage is progressively completed through the thickness of the specimen.

The first period of drying, which continues to the surface shrinkage limit, corresponds to the combined constant rate period and the first zone of the falling rate period as defined by Sherwood and others. The second period of drying, from the surface shrinkage limit to the end of drying, is equivalent to their second zone of the falling rate period.

In this interpretation of the mechanism of drying, evaporation occurs at the surface only until the surface shrinkage limit is reached; the rate of evaporation is less than that of free liquid evaporation, and no period of evaporation at a constant rate exists.

In the period following the surface shrinkage limit, evaporation occurs within the solid, the rate depending on the diffusion of vapor to the surface and through the surface air film. The position of the zone of complete saturation of the pores and maximum vapor pressure will be influenced by the relative rates of diffusion of the vapor to the surface and of diffusion of liquid (from the part of the solid in which shrinkage has not been completed) to the zone of complete saturation of the pores. This does not imply that the pores between this zone and the surface are filled only with vapor and the zone of complete saturation constitutes a plane of discontinuity between the liquid and vapor phases. The moisture gradients are continuous and indicate that the liquid phase is present throughout the mass. This is consistent with the conception of the movement of moisture through soils, according to which regions of saturation may occur side by side with regions of low moisture concentration in the system of widely varying pore sizes. The average moisture concentration in the entire cross section of the specimen can decrease continuously from the maximum concentration to the concentration at the surface.

Department of Ceramic Engineering
University of Illinois
Urbana, Illinois

Scheduled Meetings—AMERICAN CERAMIC SOCIETY

¶

Golden Gate, San Francisco, August 6–12.
The Palace Hotel.
Monday is Ceramic Day.
Banquet 6:30 P. M., Administration Building.
Atholl McBean, Speaker.
Price per plate $2.00, which includes free admission ticket to the Island for those registering. Registration $2.00.

¶

DIVISION AUTUMN MEETINGS

Art Division: Blue Ridge, N. C., August 17–18.
Enamel: Porcelain Enamel Forum, Deshler-Wallick Hotel, Columbus, October 18–20.
Glass Division: Skytop Club, Skytop, Pa., September 8 to 10.
Refractories Division: Oakland Beach Hotel, Conneaut Lake, Pa., September 8–9.
White Wares and Materials and Equipment Divisions: Summit Hotel, Uniontown, Pa., September 15–16.

¶

FORTY-SECOND ANNUAL MEETING, APRIL 7–12, 1940, ROYAL YORK HOTEL, TORONTO, CANADA

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

Ross C. PURDY, Editor

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JOURNAL REFERENCE: The journal name appears in italics, followed by the volume (bold-faced), issue number (in brackets), page numbers, and year (in parentheses).

August, 1939
18—8

Abrasives

Weld-grinding equipment. C. A. CARLSON. *Ind. & Welding*, **11**, 44–48 (Oct., 1938); *Welding Engr.*, **24**, 28–30 (May, 1939).—Grinding wheels are widely used in the preparation and finishing of joints for welding and in preparing surfaces to be hard faced. Where the work is heavy, grinding is usually done with portable equipment. If the welded parts are to be enameled or plated, all welding beads should be made smooth by grinding. Practically all portable grinding machines and most floor stands and swing-frame machines are designed to run at high speed or at a maximum speed of 9500 surface ft./min. At this speed organic-bonded (resinoid, rubber, or shellac) wheels are necessary. To grind the many kinds of work in a welding shop properly, it is advisable to have several sizes and shapes of wheels for the portable grinding machines. The wheel specification is usually 16 or 20 grit, resinoid, for general work and 20 or 24 grit, rubber-bonded, for stainless steel and other polished work. The portable sander, mounting 7 or 9 in. flexible, fiber-backed disks, is being increasingly used for polishing welded parts. The proper grain size and sequence of operations having been selected, the crossing of scratches will materially aid in attaining the desired results. Portable flexible shaft machinery for grinding and polishing reduces production and repair costs. C.E.J.

PATENTS

Abrading apparatus. E. O. HAMREN (Pangborn Corp.). U. S. 2,160,697, May 30, 1939 (Feb. 24, 1936).

Abrading apparatus. L. B. TUCHMANN AND S. J. TUCHMANN. U. S. 2,161,112, June 6, 1939 (April 7, 1938).—An apparatus for use in the cleaning of inner surfaces of metal pipe fittings.

Abrading wheel. F. J. HOHNHORST. U. S. 2,162,013, June 13, 1939 (Feb. 5, 1938).

Abrasive. N. N. SUKHAREV. Russ. 46,913, May 31, 1936; *Chem. Abs.*, **33**, 3554 (1939).—Cb_2O_5 is heated to incandescence with carbon in a H atmosphere at about 1100° and a pressure of 3 to 4 atm.

Abrasive article. HARRY C. MARTIN AND JOSEPH B. AUST (Carborundum Co.). Can. 381,150, May 2, 1939 (Sept. 23, 1937). G.M.H.

Abrasive-coated material. FRANK J. TONE (Carborundum Co.). Can. 381,149, May 2, 1939 (Oct. 22, 1935). G.M.H.

Abrasive wheel. HUGO W. H. BETH (Norton Co.). Can. 381,179, May 2, 1939 (Dec. 31, 1936). BAALIS SANFORD AND DUANE E. WEBSTER (Norton Co.). Can. 380,550, April 4, 1939 (Oct. 24, 1936); see *Ceram. Abs.*, **18** [6] 144 (1939). G.M.H.

Abrasives. RAYBESTOS-MANHATTAN, INC. Fr. 834,297, Nov. 16, 1938; *Chem. Abs.*, **33**, 3989 (1939).—A copolymer of chloroprene and a synthetic resin are used as a binding agent in the production of abrasive articles. The synthetic resin may be a cresol-formaldehyde-tung oil condensation product. The chloroprene polymer and the synthetic resin may be malaxated together with heating to form a plastic binder consisting of co-polymers of chloroprene and resin. Abrasive particles are incorporated in the binder, and the mass is formed into a grinding wheel or other article which is heated to effect further polymerization of the binder.

Arrangement for working the peripheral surfaces of grinding disks, etc. EWALD BRINKMANN AND PAUL ARNING. U. S. 2,161,609, June 6, 1939 (Dec. 12, 1936).

Binder for abrasive goods. A. P. BENDRYSHEV AND A. D. SHAPIRO. Russ. 47,897, July 31, 1936; *Chem. Abs.*, **33**, 3554 (1939).—A binder for abrasive wheels, etc., is prepared of Portland cement or alumina cement with the addition of grains of quartz, corundum, silicon carbide, etc., with or without the addition of water glass.

Buffing equipment. C. J. HAYTON. U. S. 2,160,143, May 30, 1939 (Sept. 27, 1937).

Buffing wheel. S. W. LIPPITT. Brit. 505,105, May 17, 1939 (Feb. 3, 1937). Brit. 505,107, May 17, 1939 (Dec. 24, 1936).

Buffing wheel and method of salvaging buffing wheels. H. L. Hicks (Harold L. Hicks and Hubert L. Hicks). U. S. 2,160,403, May 30, 1939 (July 26, 1938).

Cam-lapping machine. H. S. INDGE (Norton Co.). U. S. 2,162,662, June 13, 1939 (April 13, 1938).

Crankshaft grinding machine. W. H. WOOD (Norton Co.). U. S. 2,161,217, June 6, 1939 (Nov. 18, 1937).

Dressing mechanism for grinding wheels. A. H.

CANDEE AND G. O. RICHMOND (Gleason Works). U. S. 2,162,836, June 20, 1939 (June 15, 1937).

Electrothermic production of boron carbide. FRANZ SCHROLL AND ADOLF VOGT (Alexander Wacker Ges. für Elektrochemische Industrie, G.m.b.H.). U. S. 2,163,293, June 20, 1939 (Sept. 4, 1936).—A process for the electrothermic production of boron carbide comprises melting a mixture of carbon and boric acid in an electric furnace, cooling and comminuting the resulting product, mixing it with substantially the same quantity of boric acid, and melting the mixture in an electric furnace a second time.

Filler for abrasive article. A. L. BALL (Carborundum Co.). U. S. 2,162,600, June 13, 1939 (July 27, 1936).

Grinding apparatus. L. J. BAZZONI (United Shoe Machinery Corp.). U. S. 2,162,795, June 20, 1939 (Aug. 14, 1936).

Grinding device. JOHN EMERSON. U. S. 2,163,425, June 20, 1939 (Sept. 22, 1938).

Grinding or honing machine. J. H. THARP. U. S. 2,162,187, June 13, 1939 (July 18, 1938).

Grinding machine. GEORGE CROMPTON, JR., AND CLARENCE J. GREEN (Norton Co.). Can. 380,389, March 28, 1939 (Jan. 18, 1937); see *Ceram. Abs.*, **17** [2] 52 (1938). G.M.H.

Grinding machine. F. S. HAAS (Cincinnati Grinders, Inc.). U. S. 2,161,465, June 6, 1939 (Oct. 27, 1937). H. W. LARSSON. U. S. 2,160,365, May 30, 1939 (Dec. 1, 1937). G. F. MAGLOTT (Brown and Sharpe Mfg. Co.). U. S. 2,163,246, June 20, 1939 (May 18, 1937). C. L. OTT (Landis Tool Co.). U. S. 2,161,311, June 6, 1939 (Aug. 12, 1937). WINTHROP TRIBLE (Cincinnati Grinders, Inc.). U. S. 2,162,038, June 13, 1939 (May 17, 1937). W. J. WILSON. U. S. 2,162,044, June 13, 1939 (Sept. 15, 1938).

Grinding machine table reciprocating mechanism. C. G. FLYGARE (Norton Co.). U. S. 2,161,150, June 6, 1939 (March 3, 1938).

Grinding machine for tool steels with hard metal surface layer. ELBTALWERK, ELEKTRIZITÄTS-A.-G. Ger. 672,338, Feb. 9, 1939 (Feb. 29, 1936); XII/67*a*. 5.—A grinding machine for grinding tool steels with a hard surface layer is provided with a reversible motor for driving the abrasive wheel. The grinding support holding the workpiece is arranged on a swivel for turning purposes and lies parallel to the grinding-wheel axis. The pivot serving as swivel axis for the grinding support is arranged vertically under the grinding-wheel axis, and the grinding support is made wide so that the workpiece can be spread out upon it at will in such a manner that it can be turned either toward the left edge or toward the right edge of the abrasive wheel. D.A.B.

Grinding-mill device. OLAF KRISTOFFERSEN. Can. 380,278, March 21, 1939 (Jan. 15, 1937). G.M.H.

Grinding and polishing machines, etc. F. G. ROWLAND & CO., LTD., AND H. TAYLOR. Brit. 505,891, June 1, 1939 (Oct. 13, 1937).

Grinding or polishing wheels. S. W. LIPPITT. Brit. 505,106, May 17, 1939 (Dec. 24, 1936).

Grinding stones. R. S. KURNATOVSKIĬ. Russ. 47,564, June 30, 1936; *Chem. Abs.*, **33**, 3554 (1939).—Ground reed treated with NaOH to form a semicolloidal product is used for binder.

Grinding wheel. MERTON B. LANE (Norton Co.). Can. 380,846, April 18, 1939 (March 5, 1937); see *Ceram. Abs.*, **16** [3] 80 (1937). DUANE E. WEBSTER (Norton Co.). Can. 381,177, May 2, 1939 (Dec. 5, 1936). G.M.H.

Grinding wheel positioning mechanism. CARL G. FLYGARE (Norton Co.). Can. 380,840, April 18, 1939 (July 30, 1936); see *Ceram. Abs.*, **17** [2] 52 (1938). G.M.H.

Grinding wheel and method and apparatus for manufacturing. NORTON GRINDING WHEEL CO., LTD. Brit. 505,223, May 17, 1939 (Nov. 19, 1936).

Grinding wheel reciprocating mechanism. A. C. ABRAMS (Brown and Sharpe Mfg. Co.). U. S. 2,163,443, June 20, 1939 (Nov. 14, 1935).

Grindstones. NORBERT RITZINGER. Austrian 155,535, Feb. 10, 1939; 50*a*; *Chem. Abs.*, **33**, 3990 (1939).—Grindstones are made from a mixture of MgO cement with quartz sand particles of about 4 mm. diameter, and the nongrinding surfaces are coated with a mixture of quartz sand dust and MgO cement.

Hone. H. L. BLOOD (Heald Machine Co.). U. S. 2,159,962, May 30, 1939 (Nov. 4, 1936).

Honing mechanism. C. W. FLOSS. U. S. 2,160,494, May 30, 1939 (March 14, 1938).

Lapping machine. HERBERT S. INDGE (Norton Co.). Can. 380,841, April 18, 1939 (Sept. 1, 1936); see *Ceram. Abs.*, **17** [3] 92 (1938). G.M.H.

Lapping machine. F. H. MARKWICK AND L. F. POOCK (Sheffield Gage Corp.). U. S. 2,159,336, May 23, 1939 (July 5, 1935). S. M. SHAW. U. S. 2,163,438, June 20, 1939 (Aug. 19, 1938).

Lens grinding and polishing machine. E. M. LONG (Shuron Optical Co., Inc.). U. S. 2,159,620, May 23, 1939 (July 26, 1937).

Machine for surface finishing. B. F. BOWER (Howell Co.). U. S. 2,161,947, June 13, 1939 (Oct. 22, 1938).

Manufacture of abrasive belts. Durex Abrasives, Ltd. (Durex Corp.). Brit. 504,545, May 10, 1939 (Oct. 15, 1938).

Method and apparatus for grinding and polishing. H. R. HERCHENRIDER (Minnesota Mining & Mfg. Co.). U. S. 2,162,279, June 13, 1939 (July 30, 1938).

Mounted grinding wheel. MERTON B. LANE (Norton Co.). Can. 380,845, April 18, 1939 (March 5, 1937); see *Ceram. Abs.*, **16** [3] 80 (1937). G.M.H.

Package of abrasive strips. R. T. PITT (Abrasive Products, Inc.). U. S. 2,159,634, May 23, 1939 (July 19, 1938).

Polishing machine. E. R. MARTIN (Williams Co.). U. S. 2,160,885, June 6, 1939 (Nov. 8, 1935).

Production of boron carbide which is practically graphite-free. NORTON CO. Ger. 672,552, Feb. 16, 1939 (Nov. 21, 1932); IV*b*/12*i*. 37.—Graphite-free boron carbide of the formula B_4C is produced from boric acid anhydride and carbon in an electric furnace. A mixture containing the essential pure starting materials (care being taken to avoid excess of materials), in the ratio corresponding to the formula of B_4C, is heated in a nonoxidizing atmosphere (produced by an addition of readily volatile materials or substances readily decomposable by thermotic means) by an electrical resistance center to the temperatures exceeding the vaporization point of boron from the center of the furnace gradually to the exterior. See *Ceram. Abs.*, **18** [7] 170 (1939). D.A.B.

Pulpstone. THURE LARSSON (Norton Co.). Can. 381,176, May 2, 1939 (Dec. 3, 1936). Can. 381,180, May 2, 1939 (March 22, 1937). G.M.H.

Pulpstone and filler. THURE LARSSON (Norton Co.). Can. 381,178, May 2, 1939 (Dec. 10, 1936). G.M.H.

Roll-grinding machine. HERBERT J. GRIFFING (Norton Co.). Can. 380,388, March 28, 1939 (Dec. 9, 1936); see *Ceram. Abs.*, **17** [5] 171 (1938). G.M.H.

Rotary knife sharpener. SILVIO BATTOCCHI. U. S. 2,161,992, June 13, 1939 (Feb. 1, 1937).

Rubber-bonded abrasive wheel. PEHR JOHANSON (Norton Co.). Can. 380,844, April 18, 1939 (Jan. 4, 1937); see "Method—," *Ceram. Abs.*, **16** [6] 166 (1937). G.M.H.

Segmental grinding wheel. THURE LARSSON (Norton Co.). Can. 380,842, April 18, 1939 (Sept. 16, 1936); see *Ceram. Abs.*, **16** [1] 3 (1937). G.M.H.

Shaper or grinder. H. J. MCDEVITT. U. S. 2,162,630, June 13, 1939 (Jan. 13, 1939).

Spiral grinding machine. WILLIAM SHOTEY. U. S. 2,162,758, June 20, 1939 (Aug. 6, 1937).

Tool-grinding machine. F. DECKEL (trading as F. Deckel, Prazisions-Mechanik und Maschinenbau). Brit. 506,194, June 7, 1939 (Jan. 11, 1937).

Work fixture. D. R. HALL (Gardner Machine Co.). U. S. 2,159,267, May 23, 1939 (July 22, 1935; Oct. 29, 1938).

Work holder crankpin grinder. H. A. SILVEN (Norton Co.). U. S. 2,161,206, June 6, 1939 (April 23, 1938).

Art and Archeology

American scenes on glassware. ANON. *China, Glass & Lamps*, **58** [8] 11 (1939).—Designs of 100 years ago are being renewed in molded crystal glass. J.F.

Art of James Banford, painter of Derby ceramics: I. W. H. TAPP. *Connoisseur*, **99** [425] 76–80 (1937).—James Banford, son of a goldsmith and nephew of a china painter at Chelsea and Battersea, was apprenticed for seven years to Richard Champion at Bristol in 1773, but the American War and litigation troubles with a patent ended his employment there before he attained his "freedom." With Henry Bone he went to London to look for work, and until 1789 both Bone and Banford decorated china for the Chelsea Derby factory. They were invited to Derby in 1790. Banford was noted for his painting of cherubs and miniatures of classical and mythological subjects. Several of his patterns were done with Jockey Hill in 1792. **II.** *Ibid.*, [427] 206–209.—T. describes the 16 patterns assigned to Banford in the Cup and Saucer Book at the Derby factory and summarizes the characteristics that identify his paintings. Illustrated. See *Ceram. Abs.*, **14** [8] 178 (1935). M.E.P.

Blacksville High School display at World's Fair. ANON. *Bull. Amer. Ceram. Soc.*, **18** [6] 232 (1939).

Color characteristics of artists' pigments. N. F. BARNES. *Jour. Optical Soc. Amer.*, **29**, 208–14 (1939).—Fifty-one natural and artificial pigment samples were analyzed with a recording photoelectric spectrophotometer. Tristimulus values and trichromatic coefficients were computed, and the corresponding values of dominant wave-length, relative brightness, and excitation purity are compared. A.P.

Colored kitchens and bathrooms. ANON. *House Beautiful*, **81** [4] 48–51 (1939).—Helpful hints suggest to the manufacturer how his ware may be used. J.F.

Czechoslovakian ceramics influenced by the Italian Renaissance and Turkish art. Porellite, a Czechoslovakian commercial product. ALIX CORNILLE. *Céram., Verrerie, Email.*, **7** [2] 43–46 (1939); see "Imitation—," *Ceram. Abs.*, **15** [2] 67 (1936); "Decorative—," *ibid.*, **17** [7] 242 (1938). M.V.C.

Early Americana. ANON. *House & Garden*, **75** [6, Sect. 1] 53 (1939).—Colonial designers evolved original decorative forms which still influence crafts. J.F.

Early porcelain platter by Francis Gardner. H. COMSTOCK. *Connoisseur*, **100** [431] 89 (1937).—This bread and salt platter, made about 1770, antedates the important services commissioned by Catherine the Great, the first of which was ordered in 1777. Gardner went to Russia in 1746 but did not open his porcelain factory until 1765, although he had been experimenting with local clays near Moscow since about 1755. The platter is decorated with painted flower bouquets in fresh, natural colors and is bordered with bright powder blue similar to the Meissen ware, but the medallion in the center of the platter is entirely Russian in taste and treatment; it is of applied gold in several shades and is minutely chased. The letter G in underglaze blue appears on the bottom. See "Gardner—," *Ceram. Abs.*, **15** [1] 3 (1936). M.E.P.

German enameled glasses. ANON. *Connoisseur*, **99** [427] 216–17 (1937).—The full-page color illustration is accompanied by a description of six rare glass beakers made from 1592 to 1641. M.E.P.

Glassmaking in Belgium from the 12th to the 18th century. J. HELBIG. *Verre & Silicates Ind.*, **10** [6] 64–67; [7] 76–79 (1939).—The manufacture of glass and stained-glass windows was for a long time associated with the goldsmith's art and enameling, and during the 12th and 13th centuries it developed rapidly in the valleys of the Meuse and the Moselle. This association contributed to the discovery of silver yellow in the 14th century and the engraving of glass at the end of the 14th century and the beginning of the 15th century. The term "glassmaker" was used for glass painters and for manufacturers of all types of glass. All belonged to the artists' guild, which attested to the refined character of their work; many were gentlemen glassmakers. The method of preparing and melting glass is described in a manuscript by Jehan d'Oultremeuse of Liége dated 1390 which was copied in 1520 by Jan van Dixmude; recipes for black, green, red, white, and yellow used in glass painting are also given, and the furnace is described. Vinegar or linseed oil was used as a medium. The finest colored glass, however, was imported. In 1534 the first distinction between glass painters and glassmakers was made. This distinction was slow in coming because all master glassmakers were proficient in the techniques of the trade and regarded the multiple and delicate operations of glassmaking as highly as the painting of glass. To become a master glassmaker with the right to practice the trade, an apprenticeship of 2 to 4 years was required (the more noted the art center, the longer was the apprenticeship); at the end of this period the candidate was usually required to execute a painting on glass or a stained glass window of design and character prescribed by rules. Glass painting flourished during the middle of the 15th century, but by the 17th century it had ceased to be practiced. Few works remain intact today. M.V.C.

Heraldic stained glass at Gray's Inn: III. F. SYDNEY EDEN. *Connoisseur*, **100** [430] 16–20 (1937).—E. describes colored glass windows of the 16th and 17th centuries in England. Illustrated. For Parts **I–II** see *Ceram. Abs.*, **18** [7] 171 (1939). M.E.P.

History of the glass industry in Egypt and causes of its decadence. BAHRI NASSOUCHI. *Verre & Silicates Ind.*, **10** [10] 112–14 (1939).—The beginning of glassmaking was contemporaneous with that of fired brick in Egypt, and the first Egyptian brickmakers observed that when clay was subjected to prolonged and intense heat it obtained a vitrified surface in the form of a gloss or glaze. The oldest examples of this glassy substance on fired clay were discovered in the six-story pyramid at Memphis, attributed to the first dynasty and more than 6000 years old. They consist of cubes of fired clay with a vitrified surface which decorated the door of the sepulchral chamber (at present in the Berlin Museum). The Egyptians soon discovered how to prepare real glass and made vases and decorative motifs. Mural paintings show that the artisans of 2000 B.C. used the same methods employed today in manual glassmaking. There were glassworks at Thebes, Fayoun, Achmounein, and Alexandria, and their products were transported by the Phoenicians all over the known world; colored glass jewelry has been found in graves dating from the Bronze Age in Belgium, England, Germany, Hungary, Denmark, and Finland. The Assyrians and Phoenicians learned glassmaking from the Egyptians. Nero took Egyptian glassmakers to Rome and founded the first European glassworks; later, glassworks were established in the Roman provinces of Gaul, Spain, and Germany. The Egyptian glass industry again flourished in the 13th and 14th centuries but disappeared after the 15th century, by which time the rest of the world had learned the secrets of its technique. In 1933, the first important glassworks, making goblets and lamp chimneys, was founded at Choubra. With the exception of a few crudely made glass articles for tourist souvenirs, glassware is imported from Belgium, Czechoslovakia, Germany, France, Holland, Austria, and Italy (in the order of the quantity imported from each country.). M.V.C.

K'ang Hsi porcelains. H. COMSTOCK. *Connoisseur*, **99** [426] 160 (1937).—These *Famille Verte* pieces illustrating Chinese romances are a club-shaped vase with ring-molded neck and fine vitreous white glaze and two dishes marked with the hallmark of the "Hall of Green Ripples". Illustrated. M.E.P.

Landscapes on Derby porcelains. H. COMSTOCK. *Connoisseur*, **99** [425] 103 (1937).—C. describes the garniture of three Derby vases decorated with views of Scotland with the mark of the period, 1796–1814. Illustrated. M.E.P.

Lowestoft china: I, Blue and white decoration. A. J. B. KIDDELL. *Connoisseur*, **100** [432] 130–36 (1937).—Lowestoft rose to fame on the products of the Imperial Kilns at Ching-te Chen, and, as did its contemporaries,

the Lowestoft factory started with porcelain decorated in blue under the glaze in 1757. In its forty years the factory produced more than 300 patterns of tea and coffee services. Mrs. Russell Colman's collection is comprehensive and representative of the period between 1761 and 1796, the most active period of the factory, which closed about 1803. The well-known inkstand (dated 1762) belonging to Robert Browne, one of the founders and first manager of the factory, is illustrated. The pair of bottles shown was heretofore unrecorded and is the latest and most important addition to the collection. Each is painted with three typical views: St. Margaret's Church, Lowestoft; Lighthouse (High Light) and Windmill (Low Light) on the Beach; and Ship in the Roadstead. The pieces have a powder-blue ground and are of a definite type, identified by the shape of the reserved panels. The manufacture of birth tablets is peculiar to Lowestoft. About thirty are known; they vary in size from $2^{7}/_{8}$ to $4^{1}/_{2}$ in. in diameter and are perforated at the top for hanging. In 1796 the factory made enameled ware in an effort to compete with Staffordshire, and the production of blue and white ware ceased. **II, Colored decoration.** *Ibid.*, [433] 182–87.—Decoration in enamel colors appeared at Lowestoft about 1771. Richard Powles painted many of the scenes used at that time. Some of the colored peices duplicate the blue and white patterns. Attempts at armorial china were limited and unsuccessful. Figures were chiefly confined to small animals and birds as knobs on stoppers and covers. Illustrated. M.E.P.

Museum of the Hospices at Lyons, France. CHOMPRET. *Céram., Verrerie, Email.*, **7** [1] 23–30; [2] 59–61 (1939).—The collection of pharmacy jars at the Hôtel-Dieu is valuable for the study of the ceramics of Lyons; it shows the uninterrupted artistic achievements of the local faience makers from the 16th to the 19th century. Of the 400 pieces possessed by the Hôtel-Dieu, many of truly artistic character are described and illustrated. See *Ceram. Abs.*, **18** [3] 68 (1939). M.V.C.

On the site of Armageddon. ANON. *Sci. Amer.*, **160,** 285 (1939).—There are twenty levels of culture in this mound. Neolithic sherds were found in the 20th level. The 18th level (about 3000 B.C.) had a stone wall 24 ft. wide and 15 ft. high. W.D.F.

Pair of large Rouleau vases (Chih Ch'ui Ping). *Connoisseur*, **100** [430] 47 (1937).—Full-page color illustration of two vases, $19^{1}/_{4}$ in. high, of the K'ang Hsi period. They have coral-red bodies enameled in blue and aubergine with elephant-headed dragons among peonies. M.E.P.

Persian bottle. *Connoisseur*, **100** [431] 101 (1937).—Full-page color illustration of a bottle of sandy white ware with bands of black-etched inscriptions and painted black design under a crackled turquoise glaze. It is probably from Sultanabad, 13th or 14th century. M.E.P.

Persian bowl. *Connoisseur*, **100** [430] 23 (1937).—Full-page color illustration of a 13th or 14th century bowl from Sultanabad. It has a wide mouth, is of sandy white ware, and is painted with flower motifs in blue and brown-black under a clear glaze that is irregularly crazed. M.E.P.

Protais Pidoux, maker and painter of faience. CHOMPRET. *Céram., Verrerie, Email.*, **7** [2] 62 (1939).—The place of origin of a piece of faience ware can not be determined from the decoration alone because painters went from factory to factory using the same principles and manner of decorating. This is demonstrated by the career of Protais Pidoux, prolific 18th century faience painter, the dates of whose peregrinations are given. The clay body, enamel, form, color, and type of firing must be carefully studied to establish the origin of faience ware. M.V.C.

Porcelain bowl made for Paul I. H. COMSTOCK. *Connoisseur*, **99** [426] 159 (1937).—This piece from the Russian Imperial Factory is decorated with Italian views in memory of Paul's tour through Italy. It is at the Schaffer galleries. M.E.P.

Porcelain near Tehwa, South China. W. J. SUTTON. *Bull. Amer. Ceram. Soc.*, **18** [6] 234 (1939); see *ibid.*, **17** [11] 450–55 (1938).

Sang de boeuf bowl. *Connoisseur*, **100** [433] 193 (1937). Full-page color illustration of a bowl of buff stoneware, brown on an unglazed base rim. The glaze on the inside is a drab color clouded with gray, and that on the outside is a deep blood-red mottled with brown. Red tints the rim inside, and the glaze on the base is gray. It is of the Chün ware type, possibly Kwangtung, 17th century. It is in the Eumorfopoulos collection. M.E.P.

Scarabs and ushabtiu. PHILIP FAROß CLINTON. *Connoisseur*, **99** [425] 88–92 (1937).—In a historical review of the significance and occurrence of these funerary pieces used as amulets and seals and servants of the dead, C. describes some of ceramic interest. The earlier scarabs were made of dark-colored stones, such as green basalt. Later, semiprecious stones and faience were used. Many of the ushabtiu were made of the roughest clay, but in the 21st dynasty (about 1100 to 950 B.C.) the ancient Egyptians reached a high point in the production of a blue glaze. In the 26th dynasty (663 to 525 B.C.) a pale green glaze was developed. Illustrated. M.E.P.

Three gold anchor Chelsea vases. H. COMSTOCK. *Connoisseur*, **99** [426] 158 (1937).—Three urn-shaped pieces from the Symons galleries have a claret ground with decoration in gold, turquoise, and pea green. The modeling of the *amorini* and dolphins is suggestive of the work of Roubiliac. Illustrated. M.E.P.

Twenty-first annual exhibition of work by Cleveland artists and craftsmen. ANON. *Bull. Amer. Ceram. Soc.*, **18** [6] 232 (1939).

Wedgwood flowerpot. *Connoisseur*, **100** [433] cover (1937).—Full-page color illustration of one of a pair of blue jasper-ware flowerpots made by Wedgwood. It is decorated with infant Bacchanals in white relief after designs by Lady Diana Beauclerk. It is in the Lady Lever Art Gallery, Port Sunlight. M.E.P.

PATENTS

Apparatus for decorating glassware, etc. F. C. FLINT (Hazel-Atlas Glass Co.). U. S. 2,160,725, May 30, 1939 (June 14, 1938).

Culinary vessel. WILLIAM H. SAID (Corning Glass Works). Can. 380,196, March 21, 1939 (May 15, 1937; in U. S. July 6, 1936). G.M.H.

Decoration of glass and ceramic sheets, tile, etc. F. D. PARKINSON. U. S. 2,160,560, May 30, 1939 (March 30, 1938).—A method of decorating glass and ceramic products consists in first chemically cleaning the product, coating the cleaned product surface with a film of viscous solution of resin in an essential oil diluted with a volatile solvent, thereafter spraying upon the film a solid phase suspension liquid not freely miscible therewith so that drops of the suspension liquid will flocculate or coalesce into patches or group areas, distributing themselves over the film in varied shapes, heights, and sizes according to the extent to which parts of the film are wetted by the suspension liquid, and finally firing the product to volatilize the film and fuse the distributed suspension into the surface of the product.

Designs for:

Bottle. CANADIAN INDUSTRIAL ALCOHOL CO., LTD. Can. 12,324, April 15, 1939. LENTHÉRIC OF CANADA, LTD. Can. 12,269, March 11, 1939. Can. 12,323, April 15, 1939. ORANGE CRUSH CO. Can. 12,260, March 4, 1939. JOHN F. WATSON. Can. 12,326, April 15, 1939. G.M.H.

Bottle. A. C. BURGUND (Carr-Lowrey Glass Co.). U. S. 115,343, June 20, 1939 (April 20, 1939).

Coffeemaker. F. E. WOLCOTT (Silex Co.). U. S. 115,226, June 13, 1939 (Aug. 8, 1938).

Combined display carton and carrier. T. R. CAMPBELL (Corning Glass Works). U. S. 114,889, May 23, 1939 (March 1, 1939).

Cooking range. E. L. BAKER. U. S. 115,019, May 30, 1939 (April 5, 1939).

Glass bottle. JOHN H. KEENS. Can. 12,282, April 1, 1939. G.M.H.

Glass dish. M. A. SMITH (McKee Glass Co.). U. S. 115,009, May 30, 1939 (July 7, 1938).
Glass relish dish. T. C. HEISEY (A. H. Heisey & Co.). U. S. 114,895, May 23, 1939 (March 8, 1939).
Jar. FRASIER SMITH (Hazel-Atlas Glass Co.). U. S. 115,054, May 30, 1939 (Jan. 11, 1939).
Plate. LOUISE PFUHL. U. S. 115,350, June 20, 1939 (July 14, 1938). VICTOR SKELLERN (Josiah Wedgwood & Sons, Inc.). U. S. 114,908, May 23, 1939 (March 11, 1939).
Range. C. J. KESSLER (Perfection Stove Co.). U. S. 115,044, May 30, 1939 (March 21, 1938). C. F. WILEY (Glenwood Range Co.). U. S. 115,059, May 30, 1939 (Nov. 17, 1938).
Tumbler. E. W. FUERST (Libbey Glass Co.). U. S. 115,202, June 13, 1939 (Nov. 21, 1938).
Washbasin. H. A. MULLETT (Bradley Washfountain Co.). U. S. 115,001, May 30, 1939 (Oct. 10, 1938).
Etching ceramic workpieces for decorative purposes. PORZELLANFABRIK PH. ROSENTHAL & Co. A.-G. Ger. 672,533, Feb. 16, 1939 (Oct. 1, 1936); VI/80*b*. 23.05.—The desired pattern is applied with materials which are deeply fused into the surface upon heating and which enter into chemical combination with the glaze and produce readily soluble compounds which can be dissolved by inorganic or organic acids; the formation of etched places on the ceramic workpiece results. The etched places are decorated in the general manner with coloring material, gold, or silver. D.A.B.

Cements

Combined action of gypsum and lime on pozzuolanic materials. G. MALQUORI AND A. SPADANO. *Ricerca Sci.*, [2] **7, I** [5–6] 185–91 (1936).—Studies of the combined action of gypsum, lime, pozzuolanic materials, sands, and ground rocks show that the aluminous materials have the property of keeping large amounts of $CaSO_4$ whenever they undergo the combined action of gypsum and lime. The velocity of attack by the $CaSO_4$ is related to the type of binding of the Al_2O_3 in the materials examined; those containing practically no Al_2O_3 do not react with $CaSO_4$ and therefore do not form crystals of sulfur aluminate. If the $CaSO_4$ solution is kept constantly saturated, the formation of expansive sulfur aluminate is overcome by the formation of the triple salt from the constituents in solution, Al_2O_3, CaO, and $CaSO_4$. This is true for the hydrated pozzuolanic conglomerates which do not contain free $Ca(OH)_2$. V.S.M.

Control of pozzuolanic cements. C. VITTORI AND A. CERESETO. *Ricerca Sci.*, **6, II** [3–4] 75–82 (1935).—The Malquori method of control of pozzuolanic cements appears to be the most suitable and simple. It can be used only when the cement has the constitution $SiO_2 + Al_2O_3/CaO = 1$. See "Progressive—," *Ceram. Abs.*, **15** [3] 83 (1936). V.S.M.

Reactions in the solid state at high temperatures: XVIII, Tricalcium silicate, the most important constituent of Portland cement clinker. W. JANDER. *Angew. Chem.*, **51**, 696–99 (1938).—J. discusses the most important constituent of the Portland cement clinker, alite, a ternary compound for which several active states are important: (1) bodies of colloidal size and, as an intermediate state, a crystal containing somewhat less CaO than the formula $3CaO \cdot SiO$ which occur during the formation of alite; (2) a mixed crystal of $3CaO \cdot SiO_2 + 3CaO \cdot Al_2O_3$, which is unstable at ordinary temperature; the limit of miscibility is about 6 to 7% $3CaO \cdot Al_2O_3$ at 1400°C; and (3) the occurrence of cavities and tears of atomic and colloidal dimensions which result in greater reactivity with water. Tables, diagrams, and references are given. For Part **XIV** see *Ceram. Abs.*, **18** [1] 37 (1939); see also *ibid.*, p. 8. E.W.S.

PATENTS

Manufacture of cement. C. H. BREERWOOD AND J. C. WILLIAMS (Separation Process Co.). U. S. 2,161,010 and 2,161,011, June 6, 1939 (Sept. 10, 1937).

Enamel

Action of hydrogen on steel and its relation to enamel technique. ANON. *Illustr. Ztg. Blechind.*, **67** [17] 484–86 (1938); abstracted in *Referat. Silikatliteratur*, **5** [8] 5519 (1938).—During the pickling of sheet steel in HCl, the acid acts on the layer of forge scale and the following decomposition takes place: $Fe_2O_3 + 6HCl = 2FeCl_3 + 3H_2O$. Yellow ferric chloride and water are formed. Since the layer of forge scale is not equally thick throughout, the pickling acid comes in contact with the metallic iron in many places and reacts with it according to the equation $Fe + 2HCl = FeCl_2 + H_2$. Atomic hydrogen and ferrous chloride are formed. This hydrogen acts on the ferric chloride present according to the formula $2FeCl_3 + 2H = 2FeCl_2 + 2HCl$ and reduces it to green ferrous chloride. The pickling bath, therefore, is not yellow but is colored green by the ferrous compounds. The hydrogen formed in the second equation can be absorbed by the sheet steel at ordinary temperature since atomic hydrogen possesses the property of diffusing through steel at ordinary temperature. Molecular hydrogen does not possess this property. If the atomic hydrogen strikes a small empty space in its migration through the steel, two atoms of hydrogen can unite into a molecule, and the molecular hydrogen thus formed accumulates in the empty places. When atomic hydrogen flows in, it is subjected to a great pressure increase in these empty spaces, often up to 100 atm. The quantity of hydrogen absorbed by sheet steel may be the cause of defects in enameling (blisters). Frequently, these blisters occur only after repeated firing when sufficiently high pressure is reached in the spaces. The absorption of hydrogen by iron can be greatly accelerated by the addition to the bath of small quantities of arsenic, antimony, mercury, and hydrogen sulfide. The composition and the thickness of the steel affect the absorption of hydrogen. M.V.C.

Analysis of cast iron suitable for vitreous enameling. H. COWAN. *Foundry Trade Jour.*, **58** [1120] 126–28, 130 (1938).—An ideal analysis for a light casting for enameling purposes is as follows: total carbon 3.5 to 3.7, silicon 2.5 to 3.0, manganese 0.3 to 0.5, sulfur 0.06 to 0.09, and phosphorus 1.4 to 1.8%. There is no perfect analysis for enameling cast iron, however, as good enameling can be accomplished on a wide variety of compositions. The greatest troubles encountered in enameling are due to improper sandblasting, not to composition. The casting must be cleaned and properly sandblasted to give good enameling results. Local defects such as dirt, nonmetallic inclusions, gases due to iron oxide, nitrides, etc., are pointed out. **Discussion.** A. B. KENT ET AL. *Ibid.*, [1124] 205–206. H.E.S.

Application of the hydrometer method of fineness analysis to porcelain enamel slips. J. C. REIMERS. *Bull. Amer. Ceram. Soc.*, **18** [6] 195–200 (1939).

Australian foundry practice with special reference to vitreous enameling. W. THOMAS. *Foundry Trade Jour.*, **58** [1120] 121–26 (1938).—The history and development of the enamel industry in Australia is presented. The smelting and working of iron ores has been in progress only about twenty years. Raw materials for enamels are not favorably located. Feldspar, quartz, and fluorspar are found, and tin oxide is being made from Australian tin; the remaining raw materials are imported. Skilled labor is plentiful and is well organized in unions which govern wages and working conditions to a high degree. Enamel-

ing practice is similar to that employed in the U.S. but is not so highly mechanized and continuously operated. **Discussion.** D. DIXON ET AL. *Ibid.*, [1125] 225–26. H.E.S.

Combination lehr and enameling furnace. ANON. *Ceram. Ind.*, **32** [6] 34–35 (1939).—The gas-fired lehr at the Wayne Pump Co. is described. It is smaller than most lehrs, the conveyer belt being 26 in. wide and 30 ft. long, and is fired through 4 radiant tubes. It is used 4 hr. a day for decorating glass panels for gasoline pumps and 16 hr. for fusing a new low-temperature porcelain on metal pieces. The new enamel has a comparatively low silica content and is high in alkalis; it is fired at 1250° and 1220°F. Illustrated. L.C.

Effect of evacuation on ground-coat enamels. R. L. STONE AND JOHN J. AMERO. *Bull. Amer. Ceram. Soc.*, **18** [6] 200–202 (1939).

Effect of various factors upon abrasive resistance of porcelain enamels. CLARK HUTCHISON. *Bull. Amer. Ceram. Soc.*, **18** [6] 202–205 (1939). **Discussion.** C. H. COMMONS. *Ibid.*, p. 205.

Estimating, costing, and accounting. W. H. WHITTLE. *Foundry Trade Jour.*, **58** [1133] 367–69, 374 (1938).—Schemes of cost accounting generally applicable to the enamel industry are (1) the job-order system in which the costs are accumulated to a particular lot of articles, (2) the unit or monthly schedule cost in which each month's production is carried as a separate account, and (3) the process method in which the material and labor are charged to the department, and the total cost of running the department is divided by the number of pounds of finished product. A discussion is included. H.E.S.

Manufacture of enamels in the rotating ellipsoid furnace. ANON. *Verre & Silicates Ind.*, **10** [12] 136–38 (1939).—The rotating ellipsoid furnace is particularly well adapted for fusing enamels. It functions by the system of indirect heating. Rotation is continuous; the "laboratory" is almost spherical, and the axis of rotation is inclined 30° from the horizontal. The burner is placed in the axis of rotation at one of the poles of the sphere and remains fixed during rotation. The characteristics of construction and operation are given. This type of furnace assures exceptional regularity in the product obtained because of the thorough mixing and equalized fusion of the batch. See "Furnaces—," *Ceram. Abs.*, **18** [3] 69 (1939). M.V.C.

Opacifiers for vitreous enamels. G. H. ABBOTT AND L. STUCKERT. *Foundry Trade Jour.*, **58** [1116] 15 (1938).—The authors discuss the paper, "Stannic oxide as opacifier in wet enamels" (*Ceram. Abs.*, **17** [7] 246 (1938)). The results obtained can be extended to enamels in which antimony oxide is used. All the laws relating to enamels melted from hydrated alumina, potassium nitrate, and quartz can be extended to enamels containing an equivalent amount of feldspar. The more frequent occurrence of impact strains in enamels justifies the use of the impact test in practice and computation. With tin oxide, there is no real particle size distribution which could lead to a reduction of opacity during milling. S., therefore, does not recommend adding the tin oxide to the mill toward the end of the milling. The enamels mentioned fall quite closely within the expansion coefficients given by Mayer and Havas. H.E.S.

Optical aids to the enameling industry. A. H. WILLOUGHBY. *Foundry Trade Jour.*, **58** [1116] 16–18 (1938).—W. discusses the many possible applications of optical apparatus in the enamel and glass industries. Raw materials are examined microscopically, and the structure and freedom from inclusions of the enameling iron are determined. Surface examination for flaws has been improved by the use of the Ultropak, Univertor, and Epi-condenser illuminators. Examination under the microscope at elevated temperatures has been accomplished by special microscope stages. Fluorescent properties are important, especially in the glass industry where glass which is normally nonfluorescing exhibits marked fluorescence when in a state of decomposition. Surface properties are measured by means of the Leitz luminescent arc lamp and the Ultropak illuminator. Finished enamel surface glass can be measured by means of a Leifo photometer which differentiates between total reflection and diffuse reflection. The use of polarized light for determining stresses in glass is important. The problems of atmospheric pollution and industrial dust hazards have been aided by konimeter dust measurements and the Tyndallometer. H.E.S.

Optical investigation of oxide films on metals. C. E. LEBERKNIGHT AND B. LUSTMAN. *Jour. Optical Soc. Amer.*, **29**, 59–66 (1939).—Observations were made on the ellipticity resulting when plane-polarized light was reflected from iron and nickel surfaces covered with oxide films which continuously increased in thickness through the temper-color range. The method permits determination of the thickness and average optical properties of the film and may be applicable to the accurate measurement of the rate of formation of a film of any composition on a metal surface through the temper-color range. A.P.

Points relative to spraying. T. J. MACARTHUR. *Foundry Trade Jour.*, **58** [1133] 372, 374 (1938).—Factors relative to spraying are discussed, including (1) the proper air pressure, which is governed largely by the viscosity of the wet enamel, (2) good maintenance, especially cleanliness of the equipment, (3) fluttering, which may usually be overcome by proper connections on the fluid hose and by fitting a new needle in the nozzle, (4) proper handling of the ware, and (5) correct spacing of the spray booths. A discussion is presented. H.E.S.

Porcelain enameled steel fireplace. PORCELAIN ENAMELS CORP. *Steel*, **102** [15] 64 (1938).—The face and hearth of a fireplace is made of porcelain enameled steel. Illustrated. H.E.S.

Research program of the Porcelain Enamel Institute. C. S. PEARCE. *Bull. Amer. Ceram. Soc.*, **18** [6] 229–31 (1939).

PATENTS

Enameled articles. VEREINIGTE CHEM. FABRIKEN KREIDL, HELLER & CO. NFG. Austrian 155,239, Dec. 10, 1938; 48*c*; *Chem. Abs.*, **33**, 3100 (1939).—In the process wherein an article is coated with an enamel containing a gaseous opacifying agent and the edge of the article is then coated with an enamel of a different color, an improvement consists in replacing the water ordinarily used in preparing the edge enamel by another low-boiling liquid which does not dissolve the components of the enamel. Benzene, toluene, and lower alcohols or esters are suitable liquids.

Enameled articles. VEREINIGTE CHEM. FABRIKEN KREIDL, HELLER & CO. NFG. Austrian 155,240, Dec. 10, 1938; 48*c*; *Chem. Abs.*, **33**, 3100 (1939).—Articles coated with an enamel containing a solid opacifying agent are treated in the same way as in Austrian 155,239 (see preceding patent).

Enamels. IGNAZ KREIDL. Fr. 834,411, Nov. 21, 1938; *Chem. Abs.*, **33**, 3990 (1939).—Substances having an action opposite to that of the usual stabilizers are added to a concentrated enamel slip to render it of a consistency suitable for application. Phosphoric or oxalic acid or acid salts of these acids may be used as antistabilizer. The process is applicable to tin-plating enamels.

Glass, glazes, and enamels. DEUTSCHE TAFELGLAS A.-G. (Detag). Brit. 506,124, June 7, 1939 (June 29, 1938); addition to Brit. 454,189, Oct. 7, 1936.

Opacifying agents for enamels and glazes. LUDWIG WEISS (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). U. S. 2,163,334, June 20, 1939 (Jan. 5, 1938).—An enamel opacifying agent comprises a basic sulfate of cerium having a formula ranging from $4CeO_2 \cdot SO_3 \cdot H_2O$ to $4CeO_2 \cdot 3SO_3 \cdot H_2O$ together with one or more of the basic silicates selected from the group consisting of the alkali metal silicates, the alkaline earth metal silicates, and the aluminum silicates.

Producing deep-lying or raised designs on enameled articles. SOC. FRANÇAISE DES FERS EMAILLÉS. Ger. 672,327, Feb. 9, 1939 (March 22, 1937); VI/48*c*. 3.—In a method for producing designs on enameled articles, an unsintered enamel layer is applied to the previously enameled articles; by blowing a jet of a grinding or polishing material against the enameled article through the openings

of a stencil, material is partially removed; the enamel layer is then fired in. A dry enamel powder of the same character and color as the unsintered enamel layer which is applied to the article is used as the grinding material. D.A.B.

Producing enamels. ERNST POHL, GERHARD SCHMIDT, AND CHRISTIAN SCHWARZ (Buderus'sche Eisenwerke). Ger. 672,636, Feb. 16, 1939 (Dec. 10, 1936); VI/48*c*. 2.01. Basic and acidic oxides which are introduced into the enamel batch are replaced entirely or partially by bauxite. This substance takes the place of such raw materials as feldspar, kaolin, or clay. D.A.B.

Glass

Action of water on glass. G. HAUGAARD. *Glastech. Ber.*, **17** [4] 104–106 (1939).—The total soda content of Corning glass No. 015 (the most suitable for glass electrodes) can be removed in acid solution by replacement with H^+ when the glass is blown out into thin films. The Ca is only slightly replaceable. No SiO_2 is dissolved. Drying a used glass electrode tube over P_2O_5 in a vacuum causes surface layers to crack and form slivers that give a hairlike appearance. J.F.H.

Batch handling at the Streator factory, Owens-Illinois Glass Co. J. W. WRIGHT. *Glass Ind.*, **19** [6] 225 (1938); *Ceram. Ind.*, **30** [6] 52 (1938).—The batch plant consists of two adjacent rows of silos, five in each row. From the storage bins, the raw materials pass through automatic weighing equipment onto a dust-tight collecting belt and then to the mixer and into buckets, each of which holds one mixed glass batch. The glass batches are weighed and collected in cycles. All of the operations are electrically controlled. Details of the entire operation are given. E.J.V.

Bohemian glass development: I, Development of the State Technical School in Haida. II, Glass city of Steinschönau and its Technical School for the Glass Industry. H. KRAUS AND A. DORN. *Glastech. Ber.*, **17** [3] 76–81 (1939); see "We work glass—", *Ceram. Abs.*, **17** [9] 297 (1938). J.F.H.

Briquetting of the glass batch. F. G. SCHWALBE. *Ceram. Ind.*, **30** [6] 34–37 (1938); *Glass Ind.*, **19** [6] 224–25 (1938).—Briquetting of the glass batch has definitely reduced the carry-over and increased the life of the checker-brick and furnace upper structure. An increase in the life of the flux side walls, resulting from a decrease in alkalis at the glass line, is also indicated. The Ford briquetting installation is a completely automatic roll-type machine, incorporating a mixer which is used for both dry and wet mixing. The Ford Detroit plant uses silicate of soda as a binding admixture, while the Ford St. Paul plant uses hydrated dolomitic lime. Briquetting compresses the batch 30% in volume. In German blown-ware operation briquettes decreased annealing losses and glass defects. Briquetting increases the rate of melting 33%, materially reducing the fuel consumption per ton of glass produced. E.J.V.

Colloidal graphite and its utility in the glass industry. RAYMOND SZYMANOWITZ. *Glass Ind.*, **19** [6] 227–28 (1938); *Ceram. Ind.*, **31** [1] 39 (1938).—Electric-furnace graphite is of greater purity, is less cohesive, and possesses a higher oxidation point than the natural material. Being devoid of abrasive impurities and resistant to oxidation, it has the necessary characteristics of an ideal high temperature lubricant so essential in glassmaking machinery. Colloidal graphite takes on an electric charge, seemingly defies the law of gravity, and is capable of remaining with its liquid carrier under practically all conditions except evaporation, distillation, and ultrafiltration. If an aqueous dispersion of graphite is applied to a solid by brushing, dipping, or spraying, a tenacious and homogeneous film of graphite remains upon evaporation of the carrier. Such a coating has a low coefficient of expansion, is a good conductor of heat and electricity, and is unctuous, chemically inert, and highly resistant to oxidation. Turnpins, pincers, cones, and similar shaping tools for flaring tumblers and forming lips, necks, stems, and tips on glassware objects serve more effectively when graphite films are used as a parting compound. Because of the extremely fine particle size of graphite in the colloidal state, relatively small quantities (about 0.2% by weight) are required in mold applications. Application of graphited oil to parison molds working continually at high temperatures forms a perfectly smooth "graphoid" skin on the surface which considerably aids the flow of the glass and prevents sticking after the blowing operation. Colloidal graphite is also used in the polishing of molds before storage and the breaking in of new molds. See *Bull. Amer. Ceram. Soc.*, **16** [9] 281 (1937). E.J.V.

Comparison of heat-insulating materials from the economical viewpoint. FELIX VOGELER. *Gummi-Ztg.*, **51** [26] 608 (1937).—V. gives a method for comparing heat-insulating materials. Weight per unit volume, pipe diameter, coefficient of heat of the material, and price are considered. D.A.B.

Density of soda-lime silica glasses at high temperatures: II–III. I. SAWAI AND S. INOUE. *Jour. Soc. Chem. Ind. Japan*, **41** [10] 337–39B (1938).—The relationship between specific gravity and temperature in the ternary CaO–Na_2O–SiO_2 glasses can not be expressed by a straight line. An abnormal curve occurs with the devitrification of glasses with falling and rising temperature. When the SiO_2 and the Na_2O contents are constant, the specific gravity increases with the CaO content. With a CaO content of 12%, the specific gravity increases according to the Na_2O content. This behavior in the cases given is not dependent on the temperature. When the CaO content is low, the relationship is different. At low temperature, with 28 to 29% and 23 to 24% Na_2O content, the specific gravity increases with the CaO content. The specific gravity of glasses with about 6% CaO content increases with increasing Na_2O content. In the region of the softening temperature, the values for the specific gravity approach each other. At high temperature, however, the values decrease with increasing CaO or Na_2O content. For Part I see *Ceram. Abs.*, **17** [5] 181 (1938). M.V.C.

Developments in mold irons. J. S. VANICK. *Glass Ind.*, **19** [7] 263–66; [8] 308–13 (1938); *Ceram. Ind.*, **31** [1] 36–37 (1938).—V. discusses the use of nickel alloys for mold castings and deals with machinability, fine finish, density and close-grainness, prevention of sticking, low thermal expansion, high thermal conductivity, growth and scaling, and resistance to heat checking, surface deterioration, wear, corrosion, and staining of molds. He also covers means of grading and selecting cast irons for molds, together with performance data and production. E.J.V.

Evaluation and comparison of thermal conducting coefficients for heat-insulating materials. ANON. *Gummi-Ztg.*, **51** [12] 266 (1937).—A method for evaluating thermal conducting coefficients by using glass wadding, wool, and kieselguhr as materials is presented. D.A.B.

Factors insuring better mixing. E. E. MILNER AND E. E. MILNER, JR. *Glass Ind.*, **19** [6] 223 (1938); *Ceram. Ind.*, **30** [6] 37–38 (1938).—Methods of unloading and storing raw materials and the weighing, mixing, and distribution of unit batches are being developed. Increasing demands for better quality glass and uniform glass characteristics require more careful attention to the preparation of materials, which consists of careful and accurate weighing, thorough mixing, and distribution without segregation. A thorough discussion is presented. E.J.V.

Fibrous glass for electrical insulation. R. E. FERRIS AND G. L. MOSES. *Elec. Eng.*, **57** [12] 480–83 (1938).—Fibrous glass yarn is a new insulating material that will withstand high operating temperatures in electrical machines. Tests indicate that glass tape (whether treated or untreated) withstands 1.5 to 2.5 times the voltage that

asbestos stands, when both have been exposed to relatively high humidity. The only disadvantage of glass tape in comparison with the usual insulators is that it can not be wound around a sharp corner, as breakage will result. See "Glass fiber—," *Ceram. Abs.*, **18** [5] 124 (1939). P.G.H.

Fibrous glass for insulation. AMERICAN DISTRICT STEAM CO. *Steel*, **102** [17] 79 (1938).—Fibrous glass is valuable for insulating underground steam lines. The material is $^1/_2$ to $^1/_4$ the weight of other fibrous material, does not pack or disintegrate under vibration, and is unaffected by water, acids, or fumes. H.E.S.

Firing vitreous enamels on glass. H. L. CROOK. *Foundry Trade Jour.*, **58** [1116] 14–15 (1938).—Enameling on bottles is used for (1) labeling, (2) decoration, and (3) advertisement. The enamels are usually soft glazes containing a large proportion of lead and are easily spoiled by chemical reduction. As the organic media by which they are applied readily char if heated too rapidly, the first requisite is a preheating zone in which the temperature rise is not fast enough to form excessive carbon. Some ventilation to remove the fumes formed is also necessary. The softening temperature is about 600°C. A zone of controlled or slow cooling is provided to prevent strains in the glass when cooling. Illustrated. H.E.S.

Fundamentals in batch handling. A. D. SCHILLER. *Glass Ind.*, **19** [6] 222–23 (1938); *Ceram. Ind.*, **30** [6] 32–34 (1938).—S. considers the physical and chemical characteristics of the more common materials used in glass plants and discusses scales, mixers, batch wagons, sand conveyers, cullet handling, and mixing as carried out in a standard mill-type building. Other batch-handling plants are briefly described. E.J.V.

Glass batch weighing trends. A. J. JEROME. *Glass Ind.*, **19** [6] 224 (1938); *Ceram. Ind.*, **31** [1] 38 (1938).—J. traces the development of glass-batch weighing from the box filled to certain levels with each ingredient through the use of a single scale, a portable batch gathering weigh car under supply bins, and separate scales under each supply bin to the new type of automatic installation in which a single operator controls the entire batching operation from a central panel. This controls the movement of all materials from the time they leave the supply bins until they reach the furnace. E.J.V.

Glass currents in tank furnaces. W. SCHNEEKLOTH. *Glastech. Ber.*, **17** [4] 99–104 (1939).—The natural dependence between pressure distribution and mass movement in the glass bath must be the guiding principle in the interpretation of all current studies; thus, pressure difference caused by temperature difference determines the direction and the velocity of flow. By the float method of Nováky, with one float immersed to 26 cm. and a small surface float of about 4-cm. diameter used simultaneously, practically the same velocity of 1.7 m./hr. was found in the working chamber with a glass depth of 1 m. This indicates that there was no complicated rapidly moving surface currents. Results obtained from model studies can at present serve only to support views which result from direct experiments on glass tanks. J.F.H.

Glass helices for packing laboratory fractionating columns. ROBERT W. PRICE AND WILLIAM C. MCDERMOTT. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 289–90 (1939).—A simple method for the production of glass helices is described and illustrated. F.G.H.

Glass industry in Bohemia and Moravia. H. FREYTAG. *Glastech. Ber.*, **17** [4] 97–99 (1939). J.F.H.

Glass industry in Hungary. B. VON LENGYEL. *Glastech. Ber.*, **17** [4] 106–109 (1939). J.F.H.

Glass silk and mineral wool as thermic insulating material. GEORGES VIE. *Argile*, No. 192, pp. 23–25 (1939).—Insulating materials for preventing heat loss must be lightweight, nonconducting, fireproof, and not subject to deterioration or change, even at high temperatures. They include (1) glass silk, made from cullet fused at 1200° and run through holes of 3 to 5 mm., (2) mineral wool, made by forcing steam through fused slag, and (3) cellulated concrete, which is obtained by introducing a special porous mass into the liquid cement and casting the emulsion in molds. A table gives the coefficients of thermal conductivity at average temperature for 28 insulating materials. M.V.C.

Heat and cold protection. E. BORSCHKE. *Gummi-Ztg.*, **51**, 334–35, 359–60, 402–403, 487, 489 (1937).—The insulating properties of kieselguhr, magnesia, mineral wool, gypsum, spun glass, glass wadding and wool, and asbestos are discussed. B. considers the application of these materials to industrial and heating plants and dwellings. D.A.B.

Improved methods of illumination for the measurement of accidental double refraction. YNGVE BJÖRNSTÅHL. *Jour. Optical Soc. Amer.*, **29**, 201–207 (1939).—Nearly all the illumination devices hitherto used in the measurement of magnetic, electric, and mechanical double refraction induced in otherwise isotropic materials are inefficient. Methods for producing a rational illumination are described. A.P.

Luminescence of glass and study of glass structure. DENEUVILLE. *Céram., Verrerie, Émail.*, **7** [2] 47–48 (1939).—The phenomenon of the luminescence of glass observed by Becquerel and Stokes has not been systematically investigated. The tendency in the modern technique of lighting consists in using cold luminous sources, and the invisible light emitted (ultraviolet) is recovered by transforming it into visible light through fluorescent bodies, especially glasses. The theory is as follows: the irradiated energy as visible or invisible light, cathodic or Xrays, is transformed in different ways. Usually, it is employed to increase the energy of movement of the absorbing system, and the radiant energy becomes heat. Sometimes it determines chemical reactions (photochemistry); an example is the change of tint of glasses containing cerium and arsenic from the energy of the light. In certain cases the energy emitted can again be radiated. Seldom is all the energy absorbed used to excite the atoms which, as they return to their initial state, send back the total "work" received. This fluorescence has been verified with dilute vapors of sodium, mercury, and iodine. In denser mediums containing more complicated molecules, there is always a disturbance which is transformed into heat. The quantity and the quality of the light emitted are influenced by the adjacent molecules. Present knowledge about ions in a liquid applies to this theory. An active cation is paralyzed in its emissive power by its hydrated envelope; if it is protected from being near the solvent, the absorption spectrum is more marked. The solvent is also important in the case of fluorescence. If the solvent absorbs and transforms into heat a great part of the energy conveyed to an active body, the body gives a weak fluorescence and the wave length is longer. If the solvation increases, the fluorescence color approaches red. If the fluorescent molecules become more concentrated, the ratio between the luminous energy emitted and the energy received decreases (after a certain concentration). Cadmium sulfide glasses show this phenomenon clearly. The principal characteristics of luminescence in glasses according to Weyl ("Fluorescence—," *Ceram. Abs.*, **17** [10] 326 (1938)) are clearly summarized. Observations made by Tomaschek and Deutschbein ("Disclosure—," *ibid.*, [9] 302) on spectrums of fluorescence and the conclusions they reach on the structure of glasses are also given. Lines (spectral) of fluorescence permit differentiations not obtained by X-ray analysis, *e.g.*, different magnesium oxides gave different fluorescent lines, while the Debye-Scherrer roentgenograms were identical. Fluorescence lines show the true structure of electromagnetic fields in the immediate vicinity of the active atom. The phenomenon of fluorescence serves as a criterion of the crystallization and the relative purity of constituents. M.V.C.

Luminescent substances, a new type of material for light and radiation technique. N. RIEHL. *Chem. App.*, **26** [9] 137–44 (1939).—The property possessed by luminous substances of becoming luminescent under the incidence of invisible rays, *e.g.*, ultraviolet or X rays, is explained, and their preparation is described. Lenard discovered that substances can become luminescent or phosphorescent

only if they contain a small addition (about 1%) of a certain foreign substance and are as pure as possible; otherwise, the optimum of luminescence is not obtained. Especially harmful impurities are Ni and Fe of which even 1 millionth of 1% reduces the luminescence of zinc sulfide. Sulfides of the earth alkalis give the best luminescent substances; the most important commercially, however, are the silicates of the second group of the periodic system, the wolframates of the same elements, and zinc sulfide and zinc-cadmium sulfide. An addition of 0.01% Cu is made as an activating impurity to zinc sulfide. The question of the chemical structure, especially the lattice construction of luminescent substances, is not fully solved. Besides their use as luminescent screens for X-ray examinations, the substances have lately been applied to illumination technique; the glass walls of lamps (mercury, gas-filled, X-ray tubes) are coated with these substances, and 80% or more of the ultraviolet or X-ray radiation is converted into visible light. The efficiency of illumination is thus considerably increased, up to 46 lumens/watt having been obtained. The content of red rays produced is almost $^1/_3$ that of the red rays of daylight, so that objects are seen in their natural colors better than by mercury or gas light alone. Examples of installations are described. M.H.

Mold design and machine operation. G. B. Langer. *Ceram. Ind.*, **30** [6] 41–43 (1938); *Glass Ind.*, **19** [6] 215–19 (1938).—The aim of the mold designer is to make molds which will produce the greatest number of bottles of the best quality under a given set of conditions. The greatest problem in bottle production lies in the ratio of the volume of glass in the article to the internal volume of the parison mold and the relative shape of the parison to the blow mold. The ideal parison should have uniform thickness of walls with perhaps slightly greater thickness in the corners to avoid a thin spot in the sides of the finished article immediately above the base. A definite relation between the volume of glass and the volume of the parison mold gives better results. A flared parison is believed capable of producing the more stable results. Numerous ware defects and their causes which are due to mechanical fabrication and conditions of the forming machine are listed. E.J.V.

Performance of metal molds. F. W. Dixon, Jr. *Glass Ind.*, **19** [6] 227 (1938); *Ceram. Ind.*, **30** [6] 50–52 (1938).—High test cast iron can be defined as any iron having a tensile strength of 40,000 lb. or more per sq. in. The requirements of a suitable iron for the glass industry are as follows: (1) the metal must be sufficiently close-grained so that when it is machined and polished in the mold shop a high quality surface is obtained; (2) it must not be so hard that machining difficulties will seriously increase the cost of mold working; (3) it must be hard enough that it will not easily become battered or scratched in handling; and (4) it must withstand the deteriorating effects caused by contact with the hot glass. Resistance to growth, scaling, and heat checking, thermal conductivity, elasticity, and strength at elevated temperatures are other desirable properties. The effect of alloy-producing additions is pointed out . E.J.V.

Pressed-ware plant of the Corning Glass Works. H. K. Ferguson Co. *Factory Management & Maintenance*, **97** [4] B48–52 (1939).—The new plant for pressed Pyrex brand ware is built around the process with provision for future expansion. 11 photographs. J.L.G.

Reactions involved in glass grinding and polishing. E. Bayer. *Ceram. Ind.*, **31** [6] 60–62 (1938).—The process of grinding is almost exclusively in the nature of shaving (raising and removing of filings); owing to the movement of the grinding means, larger or smaller fragments of glass are torn out in shell form from the surface. The grinding means should be uniform in size and in number of cutting edges and should have great hardness, and the edged surfaces must be retained throughout the entire working process, in which the grinding material becomes reduced in size. Where the glass must be polished after grinding, the ground surface is made finer by the use of grinding material with a steadily diminishing grain. The polishing process is considered as (1) a continuation of the grinding process until a degree of fineness of such dimensions that light waves can not show a measurable straying is achieved, or (2) a surface motion, where the surface is smoothed by the flowing of the glass molecules softened by high contact temperatures. Grinding work must also be performed in the polishing in order to improve the work omitted in the grinding. Stresses in the glass may be attributed to a chemical cause, and the surface changes in the polishing due to chemical attack, even though this effect is slight compared with that of mechanical action. In the polishing of glass, the presence of both a mechanical and a chemicophysical process is shown by the fact that the working can be undertaken only with a body of a particularly suitable constitution. The polishing rouge is prepared in such a dispersed form that it is undoubtedly similar to a colloid. In polishing the surfaces of glass, reactions of a colloidal chemical nature may also be taking place. E.J.V.

Relation between fine structure and the physical properties of glasses. E. Kordes. *Glastech. Ber.*, **17** [3] 65–76 (1939).—Complete curves showing changes in molecular refraction with composition are presented for the following binary glass systems: SiO_2–PbO, B_2O_3–PbO, B_2O_3–ZnO, B_2O_3–CdO, and P_2O_5–PbO. In all cases, except for the P_2O_5–PbO system, the slopes of the curves increase with increasing molecular percentage of metal oxide. The hypothesis of Biltz *et al.*, that the total refraction of silicate glasses is additive and can be calculated from constant refraction increments (independent of concentration) for the various oxides, is, at most, valid only in limited concentration ranges. On the basis of K.'s work and that of Biltz, new equations are derived which make it possible to calculate the molecular refractions for the binary systems studied in good agreement with experimental results. These equations take into account the facts that the refraction increments for oxygen joining metal to Si, B, and P are not constant but vary with concentration and that, in the range of high metal oxide concentration, a third type of oxygen combined only to metal must be considered, whose refraction is also dependent on concentration. Some polynary glass systems are dealt with. The work is in agreement with the finding of Warren that the coordination number of B goes from 3 to 4 in glasses with bases present. J.F.H.

Safety glass. Deneuville. *Céram., Verrerie, Email.*, **7** [3] 81–83 (1939).—The composition, manufacture, and European and American varieties of safety glass are described. Sandwich glass, with an intermediate layer of (1) cellulose compounds or (2) condensation or polymerization products, and one-layer safety glasses (artificial glass, tempered glass) are discussed. M.V.C.

Solubility test for liquor bottles. Anon. *Ceram. Ind.*, **32** [6] 32–33 (1939).—New specifications issued by Joseph E. Seagram & Sons, Inc., present glass manufacturers with the problem of limiting the solubility of containers. The Seagram chemical test is described. Most manufacturers point out that the test is reliable only as a comparative test on bottles of the same size, shape, and capacity. The manufacturers' chief objection to the test is that they can, by deliberate manipulation of the batch, make bottles which will easily pass the test but will soon fail under service conditions, and that they can make bottles which will not pass the test but are perfectly satisfactory under service conditions for long periods of time. L.C.

Standardization of the luminous transmission scale used in the specification of railroad signal glasses. K. S. Gibson and G. W. Haupt. *Jour. Optical Soc. Amer.*, **29**, 188–200 (1939).—This is the first of a series of papers dealing with the development and description of signal-glass specifications resulting from coöperative efforts of the Signal Section of the Assn. of American Railroads, Corning Glass Works, and the Colorimetry Section of the National Bureau of Standards. The authors give the spectral transmissions of the basic standards (red, yellow, green, blue, purple, and lunar white glasses) on which the Assn.'s scale of luminous transmissions is based and define that scale in fundamental, absolute units. Comparison is

made with the scales defined in the 1908 and 1918 signal-glass specifications. A.P.

Surface deformation of tempered glass. N. WINTER-KLEIN. *Rev. Optique*, **17**, 377 (1938).—A study of the diffraction fringes produced by specimens of tempered glass indicates that a permanent deformation is caused by the tempering process. The deformation is not removed by annealing for periods as long as three months. The amount of deformation varies only with the axis studied. One axis usually shows a maximum deformation, and another shows a minimum or null deformation. This phenomenon correlates positively with the refractive indices along the corresponding axis. J.R.

Thermolûx glass in modern industry. ANON. *Verre & Silicates Ind.*, **10** [7] 73–76 (1939).—The comparative illuminating efficiency of Thermolux and clear glass in standard glass roofs for factories as studied in England is discussed. To obtain ideal illumination in factories, the following factors must be understood: (1) Clear glass is not suitable for glass roofs reached by the sun. (2) The glass must be symmetrical with the roof and as near the ridge as possible so that no shadows occur. (3) The angle formed by the glass surface with the point of observation, not the quantity of glass used, regulates the quantity of usable light; as a result, an angle of 30° is often more effective per square meter of glass used than an angle of 60°. (4) A table shows the probable quantity of daylight on the plane of work at a given moment, expressed in foot candles, the average outside light per month, and the light proceeding from the entire sky on an unobstructed horizontal surface. (5) The glass of the roof must be so made that the following percentage of external light is available at the work level: for fine work 15, for semifine 10, and for coarse work 5%. (6) For all practical applications, the same amount should be available for angles varying between 26° and 60°. The distance from the roof to the work level considerably affects the percentage of light transmitted. See *Ceram. Abs.*, **18** [6] 153 (1939). M.V.C.

BOOKS

Cast Glass (Gussglas). RICHARD KLAPHECK. Droste, Düsseldorf. 216 pp., 237 illustrations. Price 6.80 Rm. Reviewed in *Verre & Silicates Ind.*, **10** [9] 100–101 (1939).—The remarkably improved physical properties of the new glasses and the multiplicity of new applications of glass are dealt with. M.V.C.

Winchester bottles. British Standard Specification No. 830—1939. BRITISH STANDARDS INST., London. Price 2s.—Winchester quarts are bottles having a nominal capacity of two imperial quarts; they are fitted with ground glass stoppers. The glass may be colorless or colored and must be reasonably resistant to the chemical action of the liquids the bottles are to contain. Standard Winchester bottles are to be of specified dimensions and weight. Two sizes (nominally 80 fl. oz. and 90 fl. oz.) are recognized and are to be so marked on the base. If fluted externally, the fluted portion is to be not less than 9 in. in width, and its height is not to be less than $1^1/_2$ in. less than the height from the base to the shoulder of the bottle. If the bottle neck has external screws for metal or other caps, the threads must conform to specified dimensions. A.B.S.

PATENTS

Apparatus for:

Assembling hollow building blocks. PILKINGTON BROS., LTD. (Owens-Illinois Glass Co.). Brit. 505,033, May 17, 1939 (Nov. 3, 1937).

Chilling glass for tempering. PILKINGTON BROS., LTD. (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). Brit. 505,188 and Brit. 505,189, May 17, 1939 (Nov. 5, 1937).

Interiorly coating lamps, tubes, etc. O. H. BIGGS (Hygrade Sylvania Corp.). U. S. 2,160,714, May 30, 1939 (July 20, 1932; Dec. 31, 1937).

Removing plaster from plate glass surfacing tables. J. D. MCLEOD AND H. A. REYNOLDS (Pittsburgh Plate Glass Co.). U. S. 2,159,631, May 23, 1939 (Nov. 1, 1935).

Tempering glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 833,558 and Fr. 833,559, Oct. 25, 1938; *Chem. Abs.*, **33**, 3552 (1939). G. R. FORD, JR. (Libbey-Owens-Ford Glass Co.). U. S. 2,160,065, May 30, 1939 (Aug. 19, 1937).

Tempering glass articles. PILKINGTON BROS., LTD. (Corning Glass Works). Brit. 505,190, May 17, 1939 (Nov. 5, 1937).

Tempering sheets of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 834,514, Nov. 23, 1938; *Chem. Abs.*, **33**, 3987 (1939).

Ceramic mold. G. V. MCCAULEY (Corning Glass Works). U. S. 2,160,438, May 30, 1939 (Aug. 4, 1936).—A ceramic refractory mold is composed of a multicellular insulating refractory and coated with a layer consisting of silica, alumina, and a bond, the alumina being not more than 17% and the bond not more than 2% of the layer.

Coating glass with metal. R. D. SMITH (Corning Glass Works). U. S. 2,162,980, June 20, 1939 (Dec. 19, 1936).

Coloring and tempering glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 833,662, Oct. 27, 1938; *Chem. Abs.*, **33**, 3552 (1939).—Vitrifiable colors are deposited on the glass and vitrified by heating to the temperature necessary for tempering, and then cold air or other fluid is blown onto the glass.

Composite shatterproof window glass. H. N. ATWOOD. U. S. 2,162,598, June 13, 1939 (Feb. 9, 1937).

Compression machine for blowing glass. THOMAS C. MOORSHEAD (United Glass Bottle Manufacturers, Ltd.). Ger. 671,802, Jan. 26, 1939 (Nov. 2, 1936); VI/32*a*. 14.—A compression machine for blowing glass possesses preshaping forms revolving around a middle column on arms located on swivels in a horizontal plane, turning at times in an outer orbit for the purpose of taking up a piece of glass and revolving at times in an inner orbit for the purpose of causing the finishing forms to engage. The form components of the machine consist of a preshaping form serving at the same time as a suction form and as a pressing form, a compression device, and a finishing form for blowing the glass; the preshaping forms, which are provided with springs, come into engagement for taking up the glass during the motion in the outer orbit with a proper suction head moving vertically and, during the motion in the inner orbit, engage with a neck form and a pressing die; the blowing-out of the prepressed piece of glass takes place in the inner orbit. D.A.B.

Drawing an endless glass band from the melt. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Ger. 671,970, Feb. 2, 1939 (July 30, 1936); VI/32*a*. 23.01.—In an apparatus for drawing an endless glass band from the melt, the glass band is carried up in a vertical cooling shaft by rollers, one fixed and the other mobile; the glass is motivated by the fixed roller and pressed against the first roller by a system of levers or counterweights or a similar system. The mobile rollers are driven alternately on one side and then on the other side of the pulling or drawing device. D.A.B.

Electric furnace. F. W. ATKINSON, DALE KLEIST GAMES SLAYTER, J. H. THOMAS, AND G. M. LANNAN (Owens-Illinois Glass Co.). U. S. 2,159,361, May 23, 1939 (Nov. 30, 1936).—A method of melting and refining glass, etc., comprises establishing a body of the material, providing a localized electrical heating in an interior zone of the body to render the material in the zone very fluid and above the liquidus melting temperature of the glass, causing the material surrounding the zone to be initially heated by transmission of heat from the interior portions of the material and thereby brought to a sufficiently high temperature at which it will convey current, passing an electrical current from an external independent source through the surrounding material after it has been raised to the temperature at which it will convey current, caus-

ing the fluid material in the interior zone to be discharged, feeding the surrounding portions into the interior zone to replace the discharged fluid material, and feeding unmelted material into position to replace the material fed into the interior zone.

Electric furnace for fusing glass. HENRI GEORGE. Fr. 834,810, Dec. 2, 1938; *Chem. Abs.*, **33**, 3986 (1939).

Electric furnaces for fusing glass, minerals, etc. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 834,321, Nov. 17, 1938; *Chem. Abs.*, **33**, 3986 (1939).—The furnace is constructed so that the mass of the material to be fused is utilized as an electric resistance, and the electrodes, disposed vertically to lead the current into the bath, are provided with refractory sheaths or casings which dip into the bath.

Electric incandescent lamp. WILHELM HONING AND GILLIS OUDEMANS (Canadian General Electric Co., Ltd.). Can. 380,311, March 28, 1939 (Oct. 17, 1934). G.M.H.

Electric lamp bulb. M. A. HASSID AND HASSID, AUSTIN & CO., LTD. Brit. 506,132, June 7, 1939 (Aug. 31, 1938).

Forming machine for glass bottles, jars, etc. T. F. PEARSON (Crown Cork & Seal Co., Inc.). U. S. 2,163,103, June 20, 1939 (Nov. 18, 1936).

Furnace flue. WINTON A. TICKNOR (Corning Glass Works). Can. 380,974, April 25, 1939 (Aug. 16, 1937); see *Ceram. Abs.*, **17** [3] 107 (1938). G.M.H.

Fusion between glass, quartz, etc., and a wide metal band. HEINZ GROMADIES (Patent-Treuhand-Ges. für elektrische Glühlampen m.b.H.). Ger. 671,627, Jan. 26, 1939 (June 2, 1937) and Ger. 671,971, Feb. 2, 1939 (June 1, 1937); VI/32*b*. 10.—A method is given for fusing glass, quartz, etc., and a wide metal band for conducting current into gas and vapor discharge lamps or tubes. The metal band is fabricated into a corrugated shape in such a manner that a cross-sectional cut through the band in the direction of the width possesses a zigzag-shaped design. D.A.B.

Glass. AUSTRALIAN GLASS MANUFACTURERS CO., LTD. Australian 106,080, Dec. 22, 1938; *Chem. Abs.*, **33**, 3986 (1939).—To control the temperature and condition of molten glass in a glass-furnace forehearth, heat is applied at a plurality of spaced places along each side of a portion of the forehearth, the heat being varied from a minimum to a substantially greater amount to vary the loss of heat from the glass by radiation through the top of the forehearth. Cooling air is introduced at spaced places along each side of this portion of the forehearth above the places of heat application. The loss of heat from the glass through the top of the forehearth is thus increased. The construction of a forehearth is described in detail.

Glass. AUSTRALIAN GLASS MANUFACTURERS CO., LTD. Australian 106,456, Feb. 2, 1939; *Chem. Abs.*, **33**, 3986 (1939).—The temperature and condition of molten glass are controlled by producing a predetermined temperature gradient longitudinally in a plurality of zones in the forehearth by radiant heat, supplied through the combustion of gas and air in tunnels situated in the side walls and in the wall at the outer end of the forehearth, and by causing a reduction in temperature of a longitudinal median portion of the glass nearest the receiving end of the forehearth, by permitting loss of heat therefrom through the top structure. A furnace is described.

Glass. LEON NUSSBAUM AND STEFFI ZAMBRA. Austrian 155,129, Nov. 25, 1938; 32*c*; *Chem. Abs.*, **33**, 3095 (1939).—Glass which retains a constant transparency to ultraviolet rays for a relatively long time is made by fusing an oxide of Sr, Be, Th, Zr, or Mg with an excess of H_3PO_4. A coloring material, *e.g.*, CoO, may also be added. Specified products contain SrO 20 to 25% and P_2O_5 80 to 75% or MgO 25 to 30% and P_2O_5 75 to 70%.

Glass annealing lehr. CARROLL CONE (Surface Combustion Corp.). U. S. 2,162,377, June 13, 1939 (Nov. 26, 1934). U. S. 2,162,378, June 13, 1939 (Jan. 28, 1935).

Glass charge forming machine. WILLIAM L. MCNAMARA AND JOHN W. ERRETT (Capstan Glass Co.). Can. 380,345, March 28, 1939 (Jan. 26, 1937; in U. S. June 20, 1936). G.M.H.

Glass construction block and wall assembly. E. J. WINSHIP (Corning Glass Works). U. S. 2,162,987, June 20, 1939 (Sept. 10, 1937).

Glass-edging machine. W. J. ROBERTSON (Libbey-Owens-Ford Glass Co.). U. S. 2,160,085, May 30, 1939 (April 10, 1936).

Glass-feeding devices. J. T. WOOD. Brit. 505,440, May 24, 1939 (Nov. 9, 1937).

Glass filament spinning apparatus. HANS PINK (Patent-Treuhand-Ges. für elektrische Glühlampen m.b.H.). Can. 380,230, March 21, 1939 (Oct. 14, 1937). G.M.H.

Glass filter and method of making. H. C. BATES (Corning Glass Works). U. S. 2,160,571, May 30, 1939 (May 28, 1936).

Glass furnace. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 506,366, June 7, 1939 (July 28, 1937).

Glassmelting furnace and method of using. E. C. SULLIVAN (Corning Glass Works). U. S. 2,162,983, June 20, 1939 (June 2, 1937).

Glass mold charging devices. PILKINGTON BROS., LTD. Brit. 504,604, May 10, 1939 (Oct. 26, 1937).

Glass permeable to soft X rays and ultraviolet rays. S. D. GERIRIKEN AND K. A. TANCHAKIVSKIĬ. Russ. 47,050, May 31, 1936; *Chem. Abs.*, **33**, 3553 (1939).—The glass contains Li, B, and Be; the ratio of BeB_4O_7 to $Li_2B_4O_7$ is 1 : 1, 1 : 2, or 1 : 4.

Glass rack. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,159,672, May 23, 1939 (Oct. 22, 1937).

Glass strip grinding apparatus. FREDERIC B. WALDRON AND JAMES H. GRIFFIN (Pilkington Bros., Ltd.). Can. 380,852, April 18, 1939 (Feb. 9, 1938). G.M.H.

Glass strip producing apparatus. FREDERIC B. WALDRON, PATRICK M. HOGG, AND GRAVILLE H. BAILLIE (Pilkington Bros., Ltd.). Can. 380,681, April 11, 1939 (March 17, 1938). G.M.H.

Glass tank. J. H. MCKELVEY AND J. W. ROGERS (Laclede-Christy Clay Products Co.). U. S. 2,163,405, June 20, 1939 (July 12, 1937).

Glass-tempering apparatus. LAMBERT VON REIS (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). Can. 380,687, April 11, 1939 (Dec. 9, 1937). G.M.H.

Glass threads, etc. W. C. HERAEUS G.M.B.H. Fr. 833,356, Oct. 20, 1938; *Chem. Abs.*, **33**, 3096 (1939).—Textile threads are made of quartz glass, and these threads are woven into fabrics. A coarse filament of quartz glass may be softened by a jet of hot gas moving at a high speed and drawn out by the gas current into a fine filament.

Glass-tube cutter. WILLIAM AUCKLAND. Can. 380,429, March 28, 1939 (May 4, 1937). G.M.H.

Glass wool packing. A. D. SABORSKY (Owens-Corning Fiberglas Corp.). U. S. 2,160,001, May 30, 1939 (March 13, 1937).

Heating baths of glass by passage of electric current. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 833,530, Oct. 24, 1938; *Chem. Abs.*, **33**, 3552 (1939).

Heating device for glass lehrs, etc. L. P. PIAZZOLI, JR. (Capstan Glass Co.). U. S. 2,162,030, June 13, 1939 (April 21, 1930; July 3, 1936).

Laminated glass. MAURICE L. MACHT (E. I. du Pont de Nemours & Co., Inc.). Can. 380,364, March 28, 1939 (July 10, 1937). LOUIS PAGGI (E. I. du Pont de Nemours & Co., Inc.). Can. 380,365, March 28, 1939 (July 10, 1937). G.M.H.

Magnetic drive for lehr rolls. E. A. FUSCA (Pittsburgh Plate Glass Co.). U. S. 2,159,657, May 23, 1939 (Sept. 3, 1937).

Making filaments of pure silica, particularly quartz. F. SKAUPY AND G. WEISSENBERG. Brit. 504,883, May 17, 1939 (Aug. 19, 1937).

Manufacture of electric lamp bases from hard glass or quartz glass and incandescent lamps incorporating bases made by such process. VEREINIGTE GLÜHLAMPEN UND ELEKTRIZITÄTS AKT.-GES. Brit. 504,874, May 17, 1939 (June 25, 1937).

Manufacture of glass bottles and jars, etc. CANNING

Town Glass Works, Ltd., and J. J. Parnaby. Brit. 504,485, May 10, 1939 (Jan. 26, 1938).

Manufacture of insulating bodies. Bruno Neuhof. U. S. 2,162,386, June 13, 1939 (Dec. 30, 1935).

Manufacture of optical lenses and prisms. R. Fritz. Brit. 505,836, June 1, 1939 (March 22, 1937).

Manufacture of yarn or threads from glass filaments. Soc. Anon. Vetreria Italiana Balzaretti-Modigliani. Brit. 504,970, May 17, 1939 (April 19, 1937).

Manufacturing glass containers. J. Szanto. Brit. 505,744, June 1, 1939 (Nov. 23, 1937).

Means for mounting glass sheets upon work tables. E. A. Rosin (Libbey-Owens-Ford Glass Co.). U. S. 2,160,033, May 30, 1939 (April 29, 1938).

Means for obtaining glass fibers. Vetrocoke. Brit. 505,934, June 1, 1939 (Feb. 5, 1937).

Metal-to-glass seals. Ferranti, Ltd., and J. Dawson. Brit. 505,929, June 1, 1939 (Dec. 21, 1937).

Method and apparatus for forming large mass glassware by gob dropping. A. C. Crimmel. U. S. 2,162,800, June 20, 1939 (Jan. 24, 1935; renewed Dec. 17, 1937).

Method and apparatus for fusing characters to molded glass articles. A. G. Rez. U. S. 2,162,317, June 13, 1939 (Oct. 19, 1936).

Method and machine for forming bottoms on tubular glass blanks. L. Mellersh-Jackson (Kimble Glass Co.). Brit. 505,534, May 24, 1939 (Sept. 6, 1938).

Method and machine for forming glassware. G. E. Howard (Hartford-Empire Co.). U. S. 2,161,255, June 6, 1939 (Oct. 9, 1936).

Mold-coating apparatus. C. E. Smith. U. S. 2,145,101, Jan. 24, 1939 (July 12, 1937).

Process and apparatus for making safety glass. E. H. Haux and E. L. Fix (Pittsburgh Plate Glass Co.). U. S. 2,159,630, May 23, 1939 (March 17, 1936).

Producing ampoules. Oskar Sontag. Ger. 671,990, Feb. 2, 1939 (April 16, 1936); VI/32*a*. 27.—In a method for producing ampoules with spit running off axially, a glass tube provided with a base is pushed out by a pin or spike corresponding to the spit form, and the ampoule is fused. The production of ampoules is intended to take place continuously from glass tubes of commercial lengths; the spits of the ampoules, which form on the glass tube upon fusing of the finished ampoule produced previously, are pushed out from the base. D.A.B.

Producing double-walled glass vessels. Jakob Dichter. Ger. 672,051, Feb. 2, 1939 (March 4, 1933); VI/32*a*. 8.—In a method for producing glass vessels with narrow necks, an outer vessel is produced first on the pipe, and, by inserting a soft glass mass into the outer vessel, the inner vessel is produced. The end of the neck of the vessel is narrowed after the insertion of the inner vessel opposite the wider part of the vessel. D.A.B.

Producing mirrors from glass, etc. Max Tischer. Ger. 672,688, Feb. 16, 1939 (March 9, 1937); VI/32*b*. 10.—In a method for producing mirrors from glass, etc., the salt solution of the metal necessary for producing the mirror and the reducing solution are kept in separate containers and are applied to the article to be metallized simultaneously by an atomizer; the mixing and the reaction of the solutions occur in the atomized state. The atomizing is produced by means of steam or heated gases. D.A.B.

Producing shatterproof compound glass. I. G. Farbenindustrie A.-G. Ger. 671,862, Feb. 2, 1939 (Jan. 4, 1935); IV*c*/39*b*. 27.—Shatterproof compound glass is produced by means of a shatterproof intermediate layer of polymerized products of isobutyl vinyl ethers. D.A.B.

Producing vitreous inorganic insulating materials. Siemens-Schuckertwerke A.-G. Ger. 672,751, Feb. 16, 1939 (Feb. 4, 1936); VI/32*b*. 1.—Vitreous inorganic insulating materials for electrotechnical purposes are produced from a mixture of 30 to 60% of one or more silicates of the alkali or alkaline-earth metals or of boron, 15 to 25% aluminum oxide, 15 to 25% magnesium oxide, 8 to 15% magnesium fluoride, and 8 to 15% potassium silicofluoride, and the entire mixture is melted at a temperature of 1250 to 1300°C; it is then left to a crystallization process in which leaf-shaped soft crystals result without water of crystallization. Finally, the cooled melt cakes are crushed to coarse particles and treated with 20 to 45% (based on the entire weight of the mixture) of a pulverized glassy boric acid-lead oxide melt. The final mixture is pressed into forms at an increased temperature of 450°C. D.A.B.

Producing wire glass. Akt.-Ges. für Glasindustrie vorm. F. Siemens. Ger. 671,859, Feb. 2, 1939 (June 22, 1936); VI/32*a*. 22.—In a process for producing wire glass, the glass is rolled through two rollers (arranged over the forehearth and having their lower sections immersed in the glass mass) over a wire mesh which emerges from a nozzlelike opening under the slit of the rollers. Rollers used for rolling out the glass on the wire mesh have their surfaces occluded from the outside; they are arranged at the nozzlelike opening for introducing the wire mesh in such a manner that the glass mass, without previous formation of individual glass sheets or bands, is pushed at once over the wire mesh emerging from the nozzlelike opening and forced through the roller slit. D.A.B.

Production of tempered glass sheets. E. Ferlito. Brit. 505,857, June 1, 1939 (Sept. 25, 1937).

Purification of silica. T. E. Hooley and W. H. Reynolds. Brit. 505,178, May 17, 1939 (Nov. 2, 1937).

Quartz or glass pipe drawing apparatus. Walter Hänlein (Patent-Treuhand-Ges. für elektrische Glühlampen m.b.H.). Can. 380,231, March 21, 1939 (March 10, 1938). G.M.H.

Shaft furnace for melting quartz or glasses high in silicon-dioxide content. Walter Hänlein (Patent-Treuhand-Ges. für elektrische Glühlampen m.b.H.). Ger. 671,626, Jan. 26, 1939 (March 12, 1937); VI/32*a*. 35.—Shaft furnaces for melting quartz or glasses high in silicon dioxide content are provided with a ring-shaped drawing nozzle or jet fixed on the base of the melting receptacle for continuously removing tubes from the furnace. The furnace consists of a tubular melting receptacle of hard fusible metals such as tantalum, tungsten, or molybdenum, a jacket surrounding the receptacle with a slight gap (heated electrically), a nuclear tube of a hard fusible metal such as tantalum, tungsten, or molybdenum which forms the nozzle or ring jet with the furnace and is arranged axially in the opening of the receptacle, and three safety gas leads separated from each other; the first lead enters into the nuclear tube, the second into the upper section of the melting receptacle, and the third into the ring space between the receptacle and the surrounding heating jacket. This space is closed at the top and open at the bottom so that the safety gas lead escapes underneath, and the vapors resulting at the drawn quartz or glass tube can stop at the admission to the hot furnace parts and the resulting tube. D.A.B.

Tank furnace for melting glass. Simplex Engineering Co. Ger. 671,952, Feb. 2, 1939 (July 27, 1932); VI/32*a*. 1.—A tank furnace for melting glass has the melting, cooling, and working sections connected with each other in a line. The channel joining the melting chamber with the cooling chamber is formed only by lateral constrictions which leave open a passage extending from the base of the tank to the upper surface of the glass, and a heating unit is arranged only in the melting chamber which has the most intense heating near the passage to the cooling chamber. D.A.B.

Tempering glass. Corning Glass Works. Brit. 505,627, May 24, 1939 (Nov. 11, 1936).

Tempering glass articles. Corning Glass Works. Brit. 505,626, May 24, 1939 (Nov. 11, 1936).

Tempering glass sheets. Pilkington Bros., Ltd. Brit. 505,849, June 1, 1939 (March 13, 1937).

Treatment of glass fibers, etc. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey. Fr. 840,755, July 16, 1938; *Chem.-Ztg.*, **63** [32] 290 (1939). D.A.B.

Unbreakable glass. I. I. Kitaĭgorodskiĭ. Russ. 47,051, May 31, 1936; *Chem. Abs.*, **33**, 3553 (1939).—Two or more layers of glass with various durations of solidifica-

tion are placed on each other during the manufacturing process or while cold and are then gradually heated to complete homogenization.

Vitreous shingle. W. O. LYTLE (Pittsburgh Plate Glass Co.). U. S. 2,159,665, May 23, 1939 (Nov. 30, 1936).

Windscreens and other glass objects. S. MCMANNERS. Brit. 506,045, June 1, 1939 (Nov. 20, 1937).

X-ray tube casing. MALVERN J. GROSS (Canadian General Electric Co., Ltd.). Can. 380,159, March 21, 1939 (Jan. 4, 1935). G.M.H.

Structural Clay Products

Reinforced brickwork. CONRAD W. HAMANN AND LEONARD W. BURRIDGE. *Brit. Clayworker*, **48** [565] v–ix (1939).—The authors conclude that (1) reinforced brickwork members subjected to bending behave elastically and therefore the accepted theories and formulas for flexure are applicable to reinforced brickwork; (2) previous suggestions in regard to the mechanical characteristics of British brickwork at working loads were conservative, and while, with brick of but moderate strength, the suggested maximum permissible compressive stress of 200 lb./in.^{2} is reasonable for design purposes (subject to the special consideration of the modular ratio), with high strength brick, much higher compressive stresses (500 to 600 lb./in.^{2}) and much lower modular ratios are desirable; (3) in reinforced brickwork members subject to flexure, the primary criterion is that of shear resistance, and the ultimate compressive strength of the brickwork becomes a decisive factor only when special provision against shear is made; (4) "permanent set" at working loads is apparently independent of the type of brick and proportional to the imposed load; and (5) at certain stages of the loading, either the modular ratio or the plastic yield undergoes change. R.A.H.

Sound transmission through floors. G. W. C. KAYE. *Nat. Phys. Lab. Rept., 1938*, pp. 32–33.—Considerable progress has been made in the study of the transmission of impact noises through floors. Work on hollow-tile floors has been completed, and wood-joist floors are now being studied. The good sound-insulating qualities of a concrete floor supported on rubber have been confirmed. Wood-joist floors are inherently noisier than concrete or hollow-tile floors, but their insulation can be materially improved by the utilization of the "floating floor" principle. A floating floor in which rubber forms the insulation has been under observation for two years, but more rapid tests have been developed. Measurements have been made on a number of buildings to determine to what extent the transmission of sound through a building structure depends on the method of construction. The results have shown the important part played by the masonry and the way in which the wall is linked with the foundations; a wall insulated from its foundations apparently transmits impact noise more rapidly than one in direct contact with the foundations. The transmission of noises along water pipes can be minimized by inserting rubber connections in the pipes at suitable points. A standard noise-meter is now being produced commercially. A.B.S.

PATENTS

Brick container. W. D. MAGRUDER AND G. L. ECREMENT. U. S. 2,163,097, June 20, 1939 (April 22, 1937).

Brickmaking. G. V. MAXTED AND F. G. TIPPING. Brit. 505,679, June 1, 1939 (Dec. 8, 1937).

Brick wall construction. H. A. FABER. U. S. 2,159,019, May 23, 1939 (May 22, 1937).

Building block or brick. J. J. CANTWELL (Speedbrik Corp.). U. S. 2,160,792, May 30, 1939 (March 1, 1938).

Building brick and wall. G. B. BREAKEY (Tybrick Corp.). U. S. 2,162,417, June 13, 1939 (July 31, 1937).

Cabinet for displaying building tile. C. H. BURCHENAL (Cambridge Tile Mfg. Co.). U. S. 2,161,130, June 6, 1939 (June 21, 1937).

Cellular brick. A. MAMPAEY. Belg. 428,340, June 30, 1938; *Chem. Abs.*, **33**, 3553 (1939).—To the clay mass are added emulsifying products which produce a multitude of tiny pockets.

Drainage tile. F. S. WUELKER (Laclede-Christy Clay Products Co.). U. S. 2,162,926, June 20, 1939 (Aug. 23, 1938).

Method and apparatus for handling brick, tile, etc., during manufacture. J. DRYSDALE. Brit. 506,303, June 7, 1939 (May 2, 1938).

Self-locking building block. E. P. MARSAN. U. S. 2,163,381, June 20, 1939 (Feb. 23, 1938).

Refractories

Action of alkalis on refractory materials: X–XI. F. H. CLEWS, H. M. RICHARDSON, AND A. T. GREEN. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 9–20 (Nov., 1938).—The mechanism by which small amounts of constituent oxides of a refractory migrate to the surface of the refractory or become entirely volatilized is discussed. Experiments show that reaction of the clay or silica refractory with sodium chloride under dry conditions in an inert atmosphere favors complete volatilization. Constituent oxide migration to the surface of a refractory is favored by reaction with sodium chloride in the presence of dry air or oxygen. Conversion to chlorides takes place within the refractory, and reconversion to oxides takes place at the surface. Iron oxide so concentrated at the surface of a refractory has been found in some cases to promote carbon monoxide decomposition and growth of carbon aggregates under suitable temperature conditions. Migration and volatilization of constituent oxides are reduced considerably when reaction with sodium chloride takes place in the presence of steam. The alteration of transverse strength after exposure of various refractories to potassium chloride vapor at 1000°C is also dealt with. Appreciable changes in modulus of rupture noted in the tests do not appear to be related to the dimensional changes of the specimens. Other factors, such as development of glass phase and effect of heat treatment, intervene strongly. For Parts VIII–IX see *Ceram. Abs.*, **17** [2] 69 (1938). P.S.D.

Action of slags on refractory materials: II. W. HUGILL, R. L. AINSWORTH, AND A. T. GREEN. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 29–33 (Nov., 1938).—The authors study the corrosive action of lime alone in contact with silica, clay, and aluminous refractories. The depth of corrosion (determined by obliteration of brick structure) for clay products decreases roughly as the alumina content increases, but the depth of liquid-phase penetration beyond the zone of corrosion is at a minimum for brick of approximately normal fire-clay composition. For Part I see *Ceram. Abs.*, **17** [2] 69 (1938). P.S.D.

Attack of wood ash on refractory masonry. MARCEL LÉPINGLE. *Verre & Silicates Ind.*, **10** [5] 50–54; [6] 61–63; [8] 86–88; [9] 97–100; [10] 109–12; [11] 122–23 (1939); see *Ceram. Abs.*, **18** [1] 23 (1939). M.V.C.

Behavior of sillimanite mixes on being pressed: II. F. H. CLEWS AND A. T. GREEN. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 38–45 (Nov., 1938).—The variation of the proportioning of the various grain sizes in different parts of a pressed block is studied. Results depend on the type of pressing employed: from the top only, from top and bottom simultaneously, or from top and bottom successively. Granular constitution of the original mix markedly affects the type of variation obtained. For Part I see *Ceram. Abs.*, **15** [10] 302 (1936). P.S.D.

Carbon-lined blast furnaces. F. J. VOSBURG. *Metals*

& Alloys, **10** [4] 133 (1939).—V. states that 75% of all blast furnaces in Germany are carbon lined. One furnace has produced over 3,000,000 tons from a carbon lining, and other furnaces are expected to surpass this figure. Carbon brick are used not only in Germany, Russia, and Sweden, but in Belgium and Italy as well. The types of carbon linings generally used are (1) carbon brick in standard blast-furnace sizes; this type of lining is more satisfactory than the ceramic lining since the carbon brick are unattacked by either the slag or metal; (2) tamped or monolithic carbon lining which has been in use since 1929; (3) a furnace lining made in Germany of carbon blocks approximating 2 x 2 x 2 ft. and weighing about 800 pounds. These blocks are fired at a minimum temperature of 1100°C in furnaces such as are generally used for firing carbon electrodes. Blocks are cut and ground to exact dimensions. J.J.H.

Carbon linings for blast furnaces. FELIX SINGER. *Metals & Alloys*, **10** [4] 104–108 (1939).—S. discusses the use of carbon brick and carbon ramming masses for blast furnaces in Germany, Russia, and Sweden. Recently published figures on the efficiency of American and German blast furnaces do not show clearly that carbon brick, as a lining of the subhearth, have a longer life than the best quality firebrick used in America. American linings which consist entirely of fire-clay brick do not have a considerably shorter lifetime than German linings of which the subhearth consists of carbon brick or carbon ramming masses. The cost of carbon brick is approximately double that of fire-clay brick. Raw materials used in the manufacture of carbon brick are foundry coke and a steelworks tar free from water. The coke-tar mixture contains 1 part (by weight) of tar to about 4 to 5 parts of coke. It is heated by means of steam and rammed into a mold either by hand or by pneumatic rammers. Small shapes are formed with hydraulic presses under a pressure of 2850 to 5700 lb./sq. in. The brick are dried in 5 to 6 days and are then fired in special muffle kilns to about 1000°C. German carbon brick react neither with the slags formed in the blast furnaces nor with the alloy constituents of the pig iron. They fuse at temperatures far above cone 42. The heat conductivity of carbon brick is 15 to 20 times that of fire-clay brick. The coefficient of expansion lies within the range 0 to 900°C and is about 5.8×10^{-6}, the expansion curve being practically a straight line. The analysis must show a carbon content of 85 to 90%, and the ash content must not exceed 10%. The water absorption is about 21 to 23%, total porosity 30 to 32%, and approximate specific gravity 1.35. Russian-made brick show similar properties. Since carbon brick are unfirable only in a reducing atmosphere, linings made of fired brick or rammed masses must be protected against destruction from the starting up of the furnace until the subhearth has been filled with iron and slags. The lining, therefore, after having been built in, is covered with a layer of firebrick slabs embedded in a refractory mortar; these slabs, although soon destroyed by the iron and slags, are sufficient to protect the lining as long as there is any danger of oxidation. Parts surrounding the tap hole of the lining are masoned in fire-clay blocks. J.J.H.

Characteristics of refractories. J. F. HYSLOP. *Metal Treatment*, **4** [16] 150–52 (1938–1939).—H. points out that since a refractory consists of crystalline aggregates cemented with a glass, its structure may determine such primary characteristics as refractoriness, volume stability, strength under load, resistance to thermal shock, and corrosion resistance. Some common refractories are briefly compared. J.C.C.

Chrome ores used in the refractories industry. T. R. LYNAM AND W. J. REES. *Trans. Brit. Ceram. Soc.*, **38** [3] 211–25 (1939).—Five chrome ores were examined. A crushed high-grade ore, *i.e.*, one low in serpentine, has a low mechanical strength at high temperature due to the lack of bond, and attempts are being made to introduce the necessary bond to a high-grade ore without destroying its neutrality. In regard to ores high in serpentine, work has proceeded on converting the serpentine of low refractoriness to the higher basic form of forsterite which has a much higher refractoriness. The refractoriness-under-load tests carried out on test pieces cut from the actual ores indicate definitely that an ore high in serpentine has a low mechanical strength at high temperatures. Slag tests show that an ore high in serpentine is less neutral and tends to react more readily with the slag used than ores having a lower serpentine content. Petrological examination of the mixtures of pure MgO and Cr_2O_3 supports the assumption that the red translucent base observed in the chrome ores is chiefly $MgOCr_2O_3$ (magnochromite). Only a small proportion of the chrome ores used in the manufacture of chrome refractories is actual chromite ($FeOCr_2O_3$). R.A.H.

Classification of silicate raw materials and their application in the manufacture of Dinas block. S. V. POTAPENKO. *Soviet Geol.*, **8** [7] 71–86 (1938); abstracted in *Chem. Zentr.*, **1939, I**, 1032.—Quartz block is classified as follows: (*a*) quartzite and metamorphic quartzite, from a ground mass of crystallized aggregate or quartz grains, (*b*) cement quartzite and sedimentary quartzite sandstone, (*c*) ordinary sandstone, (*d*) brecciated layers, loose quartz deposits, and rocklike broken stone, quicksand, etc., (*e*) quartz hornstone and formations consisting mainly of microcrystalline chalcedony or secondary quartz with small amounts of clastic quartz grains, and (*f*) quartz rock and formations with amorphous SiO_2 predominating. The classification is further explained with regard to the suitability for Dinas. M.V.C.

Determination of slag attack by the crucible method. OTTO BARTSCH. *Ber. Deut. Keram. Ges.*, **19** [10] 413–26 (1938).—The German Standard test for resistance to slag attack (DIN 1069A) contains no directions regarding the rate of heating up the slag-filled crucible to the prearranged temperature. When working with very corrosive slags, a considerable portion of the crucible may be attacked during the heating-up period, and at the commencement of the actual test the slag may be very different from the original. To determine the extent to which this reaction between slag and refractory may affect the attacking properties of the slag, portions of the slag were heated to 1370° in (*a*) a corundum crucible, which is practically unattacked by the slag, and (*b*) a fire-clay crucible. The attacking power of the material was determined by immersing test bars (cross section, 10 x 10 mm.) of refractory material in both crucibles, withdrawing the bars after a given time, and measuring the reduction in the cross sections. Corrosive slags were ten times more powerful corrosive agents in the corundum crucible than in the fire-clay crucible, and the sequence of corrosive action of a number of slags in the fire-clay crucible may differ from that in the corundum crucible. Suggestions for improving the German Standard test are offered. A study of the relation between viscosity and slag attack showed that such a relationship, particularly as a function of temperature, is masked by the effect of the chemical composition of melts varying considerably in their constitution. It is therefore impossible to substitute the slag-attack test for the viscosity measurement. E.J.V.

Economies in using firebrick soaking-pit covers. BABCOCK & WILCOX CO. *Steel*, **103** [3] 66 (1938).—Patented flat soaking-pit roofs lined with lightweight insulating brick have proved successful. Such brick lighten the cover structure materially, requiring less power or lighter motors for lifting and handling. The relative ease of handling lighter covers has reduced damage to brickwork and lessened the extent and frequency of necessary repairs. Because of their low heat storage and thermal conductivity, insulating firebrick result in appreciable fuel savings in pits. Illustrated. H.E.S.

Effect of hydrocarbon gases on refractory materials: VI. E. ROWDEN. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 20–29 (Nov., 1938).—Following a study of the effects of methane and town gas in causing disruption of firebrick at about 800°C, R. deals particularly with the mechanism of the methane effect. Evidence indicates that, after a variable period of "induction" during which the iron spots are brought to the reactive condition, methane decomposes directly to

carbon and hydrogen. The carbon deposited around the iron spots and its subsequent growth into carbon aggregates disrupt the firebrick. In some cases, iron spots in firebrick are not activated, and such firebrick withstand disruption and disintegration. For Parts **IV–V** see *Ceram. Abs.*, **17** [2] 71 (1938). P.S.D.

Examination of pronounced alkali attack on silica brickwork from a vertical retort. F. H. CLEWS, W. HUGILL, AND A. T. GREEN. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 65–73 (Nov., 1938).—A vertical silica retort operating for a number of years with a salty coal at moderate carbonizing temperatures was subjected to petrographic and chemical analysis. The retort brickwork was fairly normal on the coal side but was considerably attacked on the flue side. Regions of highest temperature at the top of the retort showed considerable thinning by erosion and were thoroughly glazed. Regions of lowest temperature at the bottom showed considerable expansion, causing disintegration on the flue side. Examination indicated that the cracks and fissures caused by the expansion had become filled with molten glass draining from higher up on the retort wall on the flue side, possibly intensifying the distortion. Apparently unchanged sections from the interior of the retort brickwork showed appreciable reduction in refractoriness due to contamination with soda from the salty coal. P.S.D.

Extraction of alumina from highly aluminous raw materials: IV. S. NAGAI AND J. KATAYAMA. *Jour. Soc. Chem. Ind. Japan*, **41** [9] 310–11B (1938).—For aluminous clays with lower alumina content and high kaolinite content, the method of extracting alumina by calcining the clay with sodium carbonate was only 71 to 72% efficient and was found unsuitable. The special method of treating complex mixtures of aluminous clay with calcium carbonate and sodium carbonate is recommended in this case. For Parts **II–III** see *Ceram. Abs.*, **18** [6] 156 (1939). M.V.C.

Handling graphite crucibles. E. R. THEWS. *Chaleur & Ind.*, **19** [224] 632–36 (1938).—The expense of the highest grade crucibles is justified by savings in fuel (because of better heat transfer), in metal otherwise lost in crucible failure, and in time and labor. Rules for the care of crucibles include protection from moisture and thermal shock as well as from undue shocks and strains in handling. Careful drying of new crucibles is essential, and for the first few heats they should have only small charges. Too large a furnace is inefficient, while too small a furnace requires additional care to prevent oxidation of the crucible. Care in setting crucibles in the furnace, uniform heating, protection against oxidation by a surrounding layer of coke, and proper sizing and condition of the charge materials are discussed in detail. Flaws in crucibles may be patched with graphite-clay mixtures or with pastes containing finely powdered mica. V.D.F.

Insulation of arches of open-hearth furnaces. J. ROBITSCHEK AND F. SINGER. *Rev. Universelle Mines*, **15**, 21–29 (1939).—The desirability of insulation is discussed. Properties of refractory brick from various countries, with melting points from 900° to 1840°C, mostly above 1400°C, are tabulated. Some plants where higher temperatures were used reported little saving in fuel and no extended use of the refractory material but an intensification of the exploitation, while a majority reported a fuel economy of 5 to 30% and a saving of about 10 to 25% of the expenses for refractory materials. 27 references. E.W.S.

Jointing cements: VIII. F. H. CLEWS, H. M. RICHARDSON, AND A. T. GREEN. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 52–65 (Nov., 1938).—Twenty-two commercial jointing cements were subjected to the usual refractory tests and to tests for behavior under load and under tension at high temperatures. Measurements of the working properties of the jointing cements were also made. In general, these cements appeared to possess good, or at least adequate, workability. In some cases, however, the refractory qualities and mechanical stability are definitely inferior to those of the brick with which they would normally be used. Cements of the dry fire-clay group which showed good stability under a load of 10 lb. /sq. in. at 1300°C either contained sillimanite or were siliceous in character. For Part **VII** see *Ceram. Abs.*, **17** [2] 55 (1938). P.S.D.

Lightweight refractories. L. W. BERTELSEN. *Steel*, **103** [14] 44, 46 (1938).—Four years' continuous performance in operation of a car-type heat-treating furnace show advantages obtained with lightweight refractory brick. The furnace operates at a maximum temperature of 2150°F under positive pressure with neutral or slightly oxidizing atmosphere. At times, this is changed to a reducing atmosphere. The temperature is dropped from the maximum to 1500°F in 6 hr. and later dropped from 1550 to 1000°F within 15 min. after the charge is removed. The inner surface of the furnace is glazed with a clay which glazes at approximately 2200°F. Compared with furnaces formerly used, fuel savings of more than 45% have been obtained. Extremely uniform grain structure producing a superior roll is also obtained. The difference in temperature in any part of the furnace is less than 10°F, which insures uniform heating. H.E.S.

Manufacture of refractories. PAUL RAZOUS. *Génie Civil*, **113** [8] 217–23 (1938).—R. surveys French refractories manufacture without making any definite recommendations. The most important deposits of clays found in France and the usual application of their products are mentioned. The testing, specifications, and properties of refractories are discussed. J.D.G.

Measurement of apparent porosity. H. H. MACEY AND F. H. CLEWS. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 45–52 (Nov., 1938).—The apparent porosities of 19 specimens, covering a range of about 13 to 35%, were determined in eight ways, two of which were based on air expansion and the others on displacement, both by water and paraffin. An attempt is made to evaluate the inherent and random errors associated with each method of test. P.S.D.

Melting and softening of refractory brick as a viscosity problem. F. HARTMANN. *Ber. Deut. Keram. Ges.*, **19** [9] 367–82 (1938).—The melting, softening, and slagging of refractory brick can be regarded as phenomena taking place in the plastic and viscous states. H. reports viscosity values obtained by the method and with the apparatus of Margules. The processes involved in the sintering of brick during firing and the fusion process, either in the presence or absence of gases, alkali vapors, and liquid or solid slagging agents, are discussed, and examples are given. An important factor in this relation is diffusion, which can be simply related to viscosity. By means of thermal analyses, the cooling process and the commencement of crystal formation were studied with slags of various types in order to find the lower limit of temperature for the reactions in the viscous state. Results of the usual methods of determining the changes in viscosity in the viscous state, *viz.*, methods of determining the melting point, were compared with the results of the viscosity measurements. These measurements did not give preferential points or indicate sudden changes in the condition of the refractory materials but occurred only accidentally on the viscosity curve. In particular, a comparison of viscosity measurements and Seger cone melting-point determinations on two or more component systems (slags with chrome oxide or fluorspar, the system MnO–nSiO$_2$, enamels) showed that no rules can be given for the position of the Seger cone melting point in the viscosity curve. The values for the cone melting points are also dependent on the furnace atmosphere and the grain-size of the materials going into solution. E.J.V.

Method for calculating masonry refractories: I–II. DANIEL PETIT. *Chaleur & Ind.*, **20** [226] 239–48; [227] 273–88 (1939).—P. reviews the methods used for testing refractories in England, France, Germany, and the U. S. and discusses their disadvantages. The usual size of sample for testing refractoriness under load is too large, and there is a considerable thermal gradient from the center to the outside of the samples. The newly adopted French standard 3- x 3- x 4-cm. sample seems to give

good results. Neither the failure under constant load and variable temperature, nor the failure under variable load at constant temperature, nor failure under constant temperature and fixed load data alone give adequate information, and results are entirely misleading. P. proposes that these be considered together by plotting in a graph a series of curves showing temperature of failure against imposed load. Curves correspond to beginning of deformation and 0.5, 1, 5, and 10% deformation. The information is obtained by noting deformation temperatures with loads of 0.1, 0.25, 0.5, 1, 2, 3, 5, and 10 kg./cm.^{2} Diagrams show the furnace installation, with automatically recording pyrometers and deformation indicator. Graphs are shown for thirteen refractories, including silica, silicon carbide, sillimanite, chromite, chrome-magnesite, and magnesite. In each, the "zone of security" is shown as the area contained by the curve of beginning of deformation; from this, the safe temperature limit for any preassigned load may be read. This limit may also be read for any given tolerance of deformation by using the other curves. V.D.F.

Progress report of work of interest to gas engineers. BRITISH REFRACTORIES RESEARCH ASSN. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 73–74 (Nov., 1938). P.S.D.

Refractories in power plants. G. R. RIGBY. *Power & Works Engr.*, **32** [381] 471–75 (1937).—Power plants use 20% of all refractories. R. gives details of fire clay and the different qualities of firebrick and describes sources of failure such as slagging by the coal ashes, spalling, and deformation by the combined influence of load and temperature. Silicon carbide, silica brick, magnesite, and sillimanite and chrome refractories are described, and their physical properties are given. Tables are included. J.M.N.

Refractoriness-under-load test: VI. F. H. CLEWS, W. F. FORD, AND A. T. GREEN. *Rept. Refrac. Materials Joint Comm., 29th Rept., Inst. Gas Engrs. Commun.*, No. 193, pp. 33–38 (Nov., 1938).—The authors deal with the behavior of silica brick (materials which usually fail by shearing) under the maintained temperature-increasing load method of testing. Results are subject to appreciable variation, but average values can be used advantageously to discriminate between different brands of the class. Silica brick are unable to support a load of 50 lb./sq. in. for long periods at temperatures more than 50°C below those at which shear failure occurs in the normal method of testing. The relative merits of (1) the increasing temperature-constant load method (normal method), (2) the maintained temperature-constant load test, and (3) the maintained temperature-increasing load method are briefly discussed. The increasing-load method has a definite advantage if the average of a number of determinations can be taken; otherwise, the increasing temperature procedure is preferred. For Part V see *Ceram. Abs.*, **17** [2] 74 (1938). P.S.D.

Refractory furnace arches. J. S. MCDOWELL AND L. L. GILL. *Steel*, **102** [17] 42–48; [20] 48–50, 55–56 (1938).—Modern furnaces utilize refractory brick arches in roofs, flues, and door openings. Proper design insures maximum life and results in lower maintenance costs. Illustrations and formulas are presented showing how to figure the number and type of standard brick necessary for various refractory arch constructions. H.E.S.

Refractory insulating block. J. ROBITSCHEK AND B. HELAN. *Schweiz. Tonwaren-Ind.*, **41** [6] 3–4 (1938); abstracted in *Chem. Zentr.*, **1939, I,** 1229.—Refractory insulating block have a thermal conductivity of only 0.2 to 0.25 Cal./m. hr.° at 500°. The weight by volume is 700 to 900 kg./cu. m. They can be used at high temperatures (melting point 1770°), and their resistance to temperature change is excellent. Because of their porosity, they do not withstand the action of fused substances and are sensitive to mechanical strains. In such cases they must be used for back masonry. M.V.C.

Refractory materials for blast furnaces. A. CLAUSSET. *Rev. Universelle Mines*, **15**, 29–32 (1939).—C. discusses requirements for refractory brick and their proper selection. The desired qualities are absence of grains of iron sulfide and carbonate, low porosity, and nonsusceptibility to the action of CO. The best product should contain silica and alumina in chemical equivalence. Such material has the advantage of sustaining high temperatures. E.W.S.

Refractory mortar. JOSEPH ROBITSCHEK. *Schweiz. Tonwaren-Ind.*, **41**, 4–6 (1938); abstracted in *Chem. Zentr.*, **1939, I,** 1825.—Joints and block should be differentiated in refractory masonry although similar mixes are used for their manufacture. The most important requirement for refractory mortar is that the mortar in the joints should sinter, at the temperature to which the masonry is heated, into a compact and mechanically solid mass. This can be attained by the addition of fluxing material. Such a mortar is distinguished from the ordinary refractory in that it consists of fluxing material and thinning material instead of bond clay and thinning material. With the solution of alumina, the refractoriness of the joints increases with rising temperature. See *Ceram. Abs.*, **18** [6] 158 (1939). M.V.C.

Sagger problem in the porcelain industry. KARL MENZEL. *Sprechsaal*, **72** [1] 15–18; [2] 31–33 (1939).—M. discusses (1) foundation materials (grog, clay, and supplementary materials), (2) working of clay and preparation of sagger mix; (3) production of saggers, (4) requirements for sagger material, and (5) defects in saggers. M.V.C.

Sillimanite as a refractory for electric furnace roofs. ANON. *Iron & Steel Ind.*, **12** [4] 205–207 (1939).—The roof of the arch furnace is dealt with; no attention is paid to the body lining. Sillimanite is less extensively used than either firebrick or silica brick. Sillimanite brick may have 37 to 39% silica and 55 to 60% alumina. The iron oxide content should be about 1%. There are no standard specifications. Specific gravity is of slight significance but porosity is highly important; high porosity tends to encourage attack of roofs by erosion, corrosion, slag action, and gas permeability. Porosity may vary from 18 to 26%. After-expansion of sillimanite at elevated temperatures is often less than 0.04%/100°C rise in temperature. The most outstanding characteristic is resistance to spalling. The cost of sillimanite is approximately three times that of firebrick or silica material, but this cost is justified by the life of the roof. E.H.McC.

Thoria (ThO_2), high quality refractory. A. ESME. *Argile*, No. 193, pp. 11–13 (1939).—Thoria is extracted from thorite with HCl, and part of the foreign metals are separated with hydrogen sulfide. The residue is transformed into sulfate and purified by the formation of the double sulfate of potassium and thorium. The principal source of industrial thorium is monazite which is treated by electromagnetic tables, by sulfuric acid, and precipitation of phosphoric acid by oxalic acid. When the salts of thorium thus obtained are calcined, thoria (ThO_2) is obtained as a pure white powder, although traces of iron or rare earths may give it a yellow to brown tint. Its fusing point is 2000° to 2440° according to purity. It is highly refractory, a basic oxide, hygroscopic, absorbs gas rapidly, and is plastic. When well calcined, it is insoluble in acids. Thoria refractories have a specific gravity of 9.5 to 10 and a fusing point of 2500° to 3000°. The coefficient of expansion is high, and the reaction to silica and siliceous slags is not very good but it is not affected by basic slags. Thoria is used for incandescent mantles and special high-quality refractory crucibles; it acts as a catalyzer in certain chemical reactions. Thorium natural resources are widely distributed but always in low concentration (average thorium content of the earth's crust is 0.002% according to Joly and Clarke). This metal is found especially in Norway, Sweden, North America (the Carolinas and Texas), Brazil, Urals, Tasmania, India, and Ceylon. Thorite or orangite ($(SiO_3)_2 2Th \cdot 2H_2O$), thorianite, and monazite are the principal minerals. M.V.C.

Transformation phases of silicic acid. CLAUS KOEPPEL. *Sprechsaal*, **71** [41] 499–501; [42] 509–10 (1938); re-

printed from "Refractory Construction Materials" (*Ceram. Abs.*, **17** [9] 308 (1938)); see *ibid.*, **18** [1] 24 (1939). M.V.C.

Use of refractories in steam boilers. R. RASCH. *Ber. Deut. Keram. Ges.*, **20** [2] 74–85 (1939).—R. discusses the application of refractories in steam boilers. C.H.R.

SEPARATE PUBLICATION

Advantages in the use of high-temperature bonding mortars. J. A. PATTERSON. *Amer. Refrac. Inst. Information Circ.*, No. 1, 7 pp. (May, 1939).—P. describes the important properties of high-temperature bonding mortar and indicates the increased service that can be expected from refractory brick laid with it. High-temperature bonding mortar is defined as a mixture of refractory materials to which other materials not classified as refractories have been added for the purpose of increasing the plasticity, giving air-setting properties, or lowering the temperature at which the bond develops. Types of high-temperature bonding mortars available are (1) heat-setting and (2) air-setting. The purpose of mortar for use in laying refractory brick is to bond many relatively small units into a stable structure having strength and gas-tightness. They are shipped either in the form of a dry powder or in a wet condition. H.E.S.

PATENTS

Aluminum chloride. M. I. TEREKHOV. Russ. 47,294, June 30, 1936; *Chem. Abs.*, **33**, 3543 (1939).—A mixture of kaolin and C is chlorinated in a shaft furnace. The temperature is maintained at 1100° to 1200° by an O blast.

Aluminum hydroxide. A. A. YAKOVKIN, S. S. MARKOV, AND E. A. KREMLEVA. Russ. 46,563, April 30, 1936; *Chem. Abs.*, **33**, 3543 (1939).—Concentrated solutions of Al salts are poured into a solution of NH_4OH in water or in aqueous solutions of NH_4 salts, and the hydroxide obtained is washed in a countercurrent apparatus.

Aluminum oxide. CONSTANTIN D'ASSEEV. Fr. 832,768, Oct. 3, 1938; *Chem. Abs.*, **33**, 3543 (1939).—In making pure Al_2O_3 and NH_4Mg phosphate, the group SO_4'' of $Al_2(SO_4)_3$, and each of the two bases $Mg^{..}$ and $NH_4^{\cdot}$, or the two at the same time, constituting the salt $MgNH_4PO_4 \cdot 6H_2O$, play a double role, SO_4'' serving first for the formation of the $Al_2(SO_4)_3$ or $Al_2(SO_4)_3 \cdot (NH_4)_2SO_4$ and afterward for the precipitation, in the form of $CaSO_4$, of the third atom of $Ca_3(PO_4)_2$ during the dissolving of the group H_2PO_4'; the two bases $Mg^{..}$ and $NH_4^{\cdot}$ play, in their turn, the double role, serving first for the precipitation of the basic carbonate or hydroxide of Al and afterward for the constitution of the salt $MgNH_4PO_4 \cdot 6H_2O$.

Aluminum oxyfluoride. N. F. KASHCHEEV AND N. V. LAZAREV. Russ. 46,256, March 31, 1936; *Chem. Abs.*, **33**, 3543 (1939).—Kaolin is heated to 550° to 600°, powdered, treated with 20% H_2SO_4 at 97° to 100°, mixed with powdered CaF_2, and filtered. The filtrate is heated under pressure to 150° to 170° to precipitate $Al_2OF_4 \cdot 3.5H_2O$.

Aluminum sulfate. R. A. MANDEL. Russ. 46,255, March 31, 1936; *Chem. Abs.*, **33**, 3543 (1939).—To prepare $Al_2(SO_4)_3$ suitable for treating water, clay is decomposed by H_2SO_4 until the hot solution obtained has a gravity of 53°Bé. The solution is then poured directly into molds.

Beryllium chloride. M. A. PORTNOV AND YA. E. SEFEROVICH. Russ. 47,684, July 31, 1936; *Chem. Abs.*, **33**, 3544 (1939).—$BeCl_2$ is prepared by passing Cl through a mixture of C and Be-containing ore at elevated temperature and in the presence of univalent metals as catalysts.

Cyclic production of beryllium oxide. SERI HOLDING SOC. ANON. Fr. 833,418, Oct. 21, 1938; *Chem. Abs.*, **33**, 3544 (1939).—A mineral containing Be is subjected, *e.g.*, by heating to 550° to 800°, to the action of a reagent comprising essentially a compound containing or furnishing the group HF in such manner that the F entering into reaction becomes combined only with the Be of the mineral in the form of a simple or a complex soluble fluoride. The fluoride is converted into Be hydroxide and subsequently into BeO. The F is recovered in a proportion corresponding to that of the compound providing the HF group. The proportion of this compound used for the reaction with the Be mineral corresponds to the proportion of Be in the mineral.

Decomposing beryllium minerals, particularly beryl. GUSTAV JAEGER AND ALBERT WILLE (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). U. S. 2,160,547, May 30, 1939(Nov. 24, 1936).—In a process for decomposing beryllium-containing minerals, the step of heating such minerals in a finely divided form with material selected from the group consisting of sulfuric acid, bisulfates, and compounds of bisulfates with sulfuric acid in the presence of a quantity of a fluorine compound not more than one-tenth of the quantity which would be required to react stoichiometrically with the beryllium present in the minerals to form beryllium fluoride in a closed vessel while maintaining a pressure in such vessel substantially above atmospheric to convert the beryllium contained in the minerals substantially to beryllium sulfate.

Extraction of alumina from natural aluminum oxides and silicates. R. HANISET AND P. HANISET. Belg. 428,018, June 30, 1938; *Chem. Abs.*, **33**, 3084 (1939).—The ore is crushed after light heating, mixed with water, and treated in an autoclave with HCl. The chloride solution is filtered and crystallized, and the crystals are decomposed by pyrogenation.

Furnace-roof construction. C. F. POLLEN (M. H. Detrick Co.). U. S. 2,163,435, June 20, 1939 (Dec. 1, 1933).

Furnace-wall construction. A. C. PACIFIC. U. S 2,160,512, May 30, 1939 (March 13, 1937).

Hot top. A. C. ESTEP (Whitacre-Greer Fireproofing Co.). U. S. 2,159,374, May 23, 1939 (July 6, 1937).

Insulating material and process of manufacture. J. D. MORGAN AND R. E. LOWE (Power Patents Co.) U. S. 2,161,186, June 6, 1939 (Sept. 15, 1936).—(5) A process for producing a hard porous silica insulator comprises preparing granular silica hydrogel, incorporating therewith a relatively small proportion of an alkali salt impurity, and rapidly heating the hydrogel to a relatively high temperature, thereby producing substantially anhydrous silica pellets. (8) A bonded insulating material comprises preformed hard silica pellets having a high degree of porosity, the pellets being bonded together with a bonding agent and cast in the desired shape.

Insulating and refractory brick. BABCOCK & WILCOX CO. Fr. 834,121, Nov. 14, 1938; *Chem. Abs.*, **33**, 3553 (1939).—A moist mixture of the solid constituents and water is made, and the desired shape is imparted by injection molding. The shaped articles are subjected to the firing process while they are still humid. The solid constituents of the mixture may comprise pulverized kaolin, sawdust, and a setting agent or hydraulic binder such as plaster of Paris.

Manufacture of ceramic silicon ware. M. HAUSER. Brit. 505,173, May 17, 1939 (Oct. 6, 1936).

Manufacturing aluminum sulfate from kaolin. N. MARTINET, C. BOGDANOFF, AND SOC. A R. L. LABORATOIRE EGÉ. Brit. 494,490, Nov. 9, 1938 (March 24, 1938).

Method for constant disintegration of bauxite. VEREINIGTE ALUMINUM-WERKE A.-G. Ger. 665,495, Sept. 8, 1938 (Feb. 2, 1935); IV*b*/12*m*. 5.—A method for constant disintegration of bauxite comprises treating with NaOH at high temperatures and under increased pressure. The bauxite, which is stored in pressure-tight towers, is treated with hot NaOH at a temperature of 160°C or higher. D.A.B.

Method and means for sintering or fritting refractory linings by means of an electric arc. A. L. SADLER (Pittsburgh Lectromelt Furnace Corp.). Brit. 505,292, May 24, 1939 (Feb. 2, 1938).

Refractories. P. P. BUDNIKOV. Russ. 47,932, July 31, 1936; *Chem. Abs.*, **33**, 3554 (1939).—$CaCl_2$ or a mixture of CaO and $CaCl_2$ is added to the material used in the manufacture of refractories to increase the strength of the finished product.

Refractory material. HANS KERLA. U. S. 2,160,873, June 6, 1939 (May 22, 1935).—As a new composition of

matter, a raw refractory mix adapted to be formed into a fired article consists of a member of the sillimanite group and an alkali silicate of about 36 to 41° Bé, the latter being insufficient to adversely affect the strength of fired products made therefrom and the refractory characteristics under service conditions of fired products.

Refractory material. J. D. SULLIVAN (Battelle Memorial Inst.). U. S. 2,160,923, June 6, 1939 (Feb. 11, 1937). A refractory material consists of barium oxide and silica in total proportion of 5 to 35% of the entire mass, and the remainder is substantially all magnesium oxide.

Refractory material. J. D. SULLIVAN (Battelle Memorial Inst.). U. S. 2,160,924, June 6, 1939 (Feb. 11, 1937; May 24, 1937).—A method of making a refractory material comprises mixing raw magnesite, barium oxide, and silica in such proportions that on subsequent heating the resulting product will be characterized by having magnesium oxide as its principal constituent and heating to effect decomposition of the magnesite, combination of the barium oxide and silica, and dead burning of the magnesia.

Removable top for soaking pits. W. T. DEAN. U. S. 2,159,844, May 23, 1939 (May 17, 1937; Aug. 12, 1937).

Silica-free aluminate. A. P. ZNOIKO. Russ. 46,561, April 30, 1936; *Chem. Abs.*, **33**, 3543 (1939).—Bauxite is fused with Na_2CO_3 or CaO, and the melt is leached at 60 to 75°. SiO_2 is removed from the filtrate by addition of CaO.

Treatment of aluminum ores. ISTVÁN HUNYADY. U. S. 2,160,148, May 30, 1939(April 2, 1936).—The method of working, by chemical treatment, an ore, or a material obtained by decomposing an ore, containing, besides aluminum compounds in substantial proportion, compounds of iron and certain other metals comprises mixing the material with ammonium sulfate, heating the mixture thus obtained to develop ammonia and produce, from metal compounds contained in the starting material, metal sulfates which are soluble in water, dissolving the metal sulfates in acidulated water, separating the solution thus obtained from any insoluble constituents, adding ammonium sulfate to this solution and concentrating it, causing the dissolved aluminum sulfate to crystallize out substantially pure in the form of ammonia alum, separating the precipitate thus obtained from the mother liquor (I), reducing any ferric compound dissolved in the mother liquor and then adding to the mother liquor a solution of ammonium sulfate, causing the main part of the iron sulfate present in the liquid mixture thus obtained to crystallize out in the form of ammonium ferrous sulfate in admixture with ammonium alum, separating from the precipitate thus obtained the mother liquor (II) which is an aqueous solution of ammonium sulfate, introducing into mother liquor II ammonia, filtering off the precipitate thereby formed, and washing it with a solvent for a metal hydroxide contained in the last-mentioned precipitate.

Terra Cotta

Making sanitary pipe. W. H. B. *Brit. Clayworker*, **48** [565] 41–44 (1939).—B. discusses grinding of clay, making of pipe, molding, drying, setting of kilns, and firing. R.A.H.

Materials for sewerage pipes. FELIX SINGER. *Trans. Brit. Ceram. Soc.*, **38** [4] 257–80 (1939); see *Ceram. Abs.*, **18** [6] 154 (1939). R.A.H.

Stoneware: classification and manufacture. G. V. *Argile*, No. 193, pp. 21–23 (1939).—Stoneware may be classified according to the flux used to impart necessary fusibility, *i.e.*, as alkaline, calcareous, or ferruginous. The first type is important in industry and it is made with micaceous clay with a high quartz content which acts as a natural leaning agent. Stoneware is usually covered by a thin glaze to improve its appearance, but an enamel coat composed of feldspar with borax or limestone is necessary to make it impermeable. Clay of Saint-Amand (Niévre, France) used for stoneware contains kaolinite 35, mica 25, and quartz 40. M.V.C.

PATENTS

Filter tile. L. M. CHRISTIE, E. F. WANNER, AND A. S. BREWER (National Fireproofing Corp.). U. S. 2,161,999, June 13, 1939 (March 23, 1935).—A trickling filter floor comprises rows of hollow filter blocks in end to end relation, each having a plurality of partition walls dividing the hollow blocks into parallel drain troughs extending longitudinally of the blocks and rows to provide uninterrupted flow passages through successive blocks, the top of the blocks having horizontal walls provided with slots transversely of the drain troughs and extending below the top wall of the partition walls to form a grid structure to support a filtering bed thereon.

Roofing tile. F. H. KAWAMURA. U. S. 2,160,548, May 30, 1939 (Sept. 15, 1937).

Whiteware

Action of potash mica in porcelain masses. R. RIEKE AND PU-YI-WEN. *Ber. Deut. Keram. Ges.*, **20** [2] 43–73 (1939).—A possible method for the determination of the mica content and a method for separating mica from kaolin and clay, previous knowledge of the influence of muscovite upon kaolin and ceramic body properties such as plasticity, casting ability, and firing, and the determination of the influence of muscovite content upon the firing characteristics and properties of hard porcelain are discussed. Sixteen clay-feldspar-flint-mica bodies were studied. The authors determined the shrinkage at 1100°C, the relationship of shrinkage and apparent porosity to the firing temperature, and the relationship of specific gravity to composition, firing temperature, and firing schedule. Fired properties such as thermal expansion, load softening point, bending strength, and fired microscopic structure were also studied. Curves, tables of results, and a bibliography are presented. C.H.R.

Behavior of high-voltage insulators on radio test. CHARLES J. MILLER, JR. *Elec. World*, **111** [12] 45–48 (1939).—The radio-interference characteristics of a porcelain insulator are usually determined by applying a voltage to the insulator and measuring the amount of radio interference at that voltage. Tests show the effect of humidity and indicate that the relations between corona and radio interference are not as close as formerly believed. E.H.McC.

Chinaware glazes containing lead not necessarily a health hazard. ANON. *Bull. Amer. Ceram. Soc.*, **18** [6] 233 (1939); see *Jour. Amer. Ceram Soc.*, **22** [4] 133–40 (1939).

Clayworks progresses. ANON. *Power & Works Engr.*, **32** [377] 307–309 (1937).—Progress made in the pottery of Candy & Co., Ltd., at Heathfield, England, since 1928 (*ibid.*, Oct., 1928) is described. Two new Dressler kilns of the tunnel type are mentioned, and a detailed description is given of a producer gas plant, power plant, belt drive for tileworks and clay preparation, engines in clayworks, and a stand-by oil-engine set. The clayworks employs 400 men. Illustrated. J.M.N.

Final progress report on plastic primary North Carolina kaolins, methods of their use, development of vitreous bodies, and experiments with a continuous, high-temperature, electric tunnel kiln: I, A year's testing of plastic-type North Carolina primary kaolins. R. E. GOULD AND A. J. HEDQUIST. *Jour. Amer. Ceram. Soc.*, **22** [7] 205–207 (1939). **I [Supplement], Comparative study of acid- and base-binding capacities and viscosity relations in (A) and**

(B) clays. E. C. HENRY. *Ibid.*, pp. 207–10. **II, Further development and testing of a true porcelain and vitreous china dinnerware body using North Carolina kaolin as the chief plastic constituent.** R. E. GOULD AND A. J. HEDQUIST. *Ibid.*, pp. 210–13. **III, Casting all-kaolin bodies.** A. J. HEDQUIST, E. WILSON, AND R. E. GOULD. *Ibid.*, pp. 214–15. **IV, Laboratory experiments in the production of flatware.** R. E. GOULD AND G. W. FICHTER. *Ibid.*, pp. 216–19. **V, Electric kilns and furnaces.** R. E. GOULD, M. G. TOOLE, AND M. S. NELSON. *Ibid.*, pp. 220–37. **VI, Heat balance on pilot kiln.** M. G. TOOLE AND M. S. NELSON. *Ibid.*, pp. 238–39. **VII, Probable heat loss and efficiency of a theoretical commercial electric kiln.** M. G. TOOLE AND M. S. NELSON. *Ibid.*, pp. 240–45; see *ibid.*, **20** [6] 175–214 (1937).

Material used in communications. E. BUCHWALD. *Siemens-Z.*, **17** [9] 484–86 (1937).—B. reviews materials used for telephones and telegraphs, including steatite, porcelain, and light metals for conductors and cases. J.M.N.

Midland Electric Mfg. Co. factory at Tyseley. ANON. *Power & Works Engr.*, **33** [382] 11–16 (1938).—The power supply, lighting, foundry, porcelain manufacture, and assembly are discussed. The five raw materials received by the porcelain plant are handled mechanically within the plant. Some of the presses are entirely automatic and some are handoperated. The gas-fired kiln is 135 ft. long, with Cambridge automatic control actuating motorized gas and air valves; a temperature of 1250°C is possible. The work consumes 60 million cu. ft. of town gas a year. Dust is taken away with exhausts by duplicate motor-driven fans. J.M.N.

New types of raw quartz material for the earthenware industry. HANS LEHMANN AND HEINZ MIELDS. *Ber. Deut. Keram. Ges.*, **19** [11] 433–61 (1938).—The possible usefulness of waste sand from the kaolin-washing process was investigated. Waste sands and raw kaolins of German origin were studied in an attempt to dispense with imported Danish flint. Their behavior when fired in industrial earthenware kilns (particularly the degree of inversion of β-quartz to β-cristobalite) and when incorporated in earthenware bodies was determined. Chemical analyses of the waste sands showed that they contain sufficient SiO_2 and a certain proportion of those oxides and minerals which are known to favor cristobalite inversion. The results of optical and X-ray examinations of the raw and fired materials are reported. It is impossible to separate the β-quartz fraction from the β-cristobalite fraction either by the settling method or by the use of a centrifuge. The light portion from the centrifuge was almost pure cristobalite (shown by the X-ray diagram), but the heavy portion also showed strong β-cristobalite interferences as well as β-quartz lines. X-ray diagrams show that there was no tridymite formation. An attempt was made to determine quantitatively the amount of β-cristobalite formed, by specific-gravity measurements by the suspension method, using as the liquid acetylene tetrabromide adjusted with xylol. After firing to cone 9 to 10 all the materials had lower specific gravities. Danish flint had a β-cristobalite content of 79% while the two best sands had a content of approximately 50%. E.J.V.

Silica in earthenware. T. SIMPSON AND H. W. WEBB. *Trans. Brit. Ceram. Soc.*, **38** [3] 226–44 (1939).—The important differences between flint and quartz in regard to their effect in pottery bodies are connected with the following phenomena: (*a*) effect of heat, (*b*) α-β cristobalite inversion, (*c*) α-β quartz inversion, (*d*) expansion of the body, and (*e*) rate and extent of vitrification. These are discussed. R.A.H.

Symposium on "Organic electrolytes, wetting and plasticizing agents for cast, dry-press, and plastic bodies": I, Use of an ammoniacal electrolyte for a plastic body. J. W. HEPPLEWHITE. *Bull. Amer. Ceram. Soc.*, **18** [6] 191–92 (1939). **II, Practical problems related to the use of No. 2 deflocculent in a vitrified china body.** R. C. ANDERSON. *Ibid.*, p. 192. **III, Advantages of deflocculent No. 2 in casting slips.** R. J. GREENE. *Ibid.*, p. 193. **IV, Organic deflocculents for casting slip.** F. C. HENDERSON. *Ibid.*, pp. 193–95.

PATENTS

High-potential terminal. H. M. HOBART (General Electric Co.). U. S. 2,160,660, May 30, 1939 (Sept. 23, 1937).

Insulator. J. J. TAYLOR. U. S. 2,162,288, June 13, 1939 (March 9, 1938).

Manufacture of spark plugs. D. H. CORBIN (General Motors Corp.). U. S. 2,162,062, June 13, 1939 (March 17, 1938).

Spark plug. HARRY H. ARMSTRONG AND ARTHUR B. MENEFEE. Can. 381,063, May 2, 1939 (Aug. 3, 1937). JOHN GABLER. Can. 381,077, May 2, 1939 (Nov. 17, 1937). G.M.H.

Spark plug. H. F. FRUTH (P. R. Mallory & Co., Inc.). U. S. 2,159,791, May 23, 1939 (April 20, 1937). J. GABLER. Brit. 505,085, May 17, 1939 (Oct. 28, 1937). H. L. HALL. U. S. 2,163,362, June 20, 1939 (May 9, 1938).

Equipment and Apparatus

Cinematography with a high-temperature microscope. T. SWINDEN, T. W. HOWIE, AND J. H. CHESTERS. *Trans. Brit. Ceram. Soc.*, **38** [4] 245–56 (1939).—A high temperature microscope is described which consists essentially of a furnace with water-cooled lid and fused-silica window, a metallurgical microscope, a Mikrophot attachment for simultaneous viewing and filming of the subject, and a cinematograph camera. The application of this equipment to the determination of melting points and the study of slag reactions is discussed. Bloating, dehydration, and calcining were observed. A record has been made on 16-mm. film of the more interesting reactions, the maximum temperature used in this part of the work being 1600°C. R.A.H.

Coal grinding conical ball mills. ANON. *Fuel Economist*, **12** [140] 276–78 (1937).—The operating characteristics of conical ball mills in conjunction with air classifiers are discussed. Illustrated. F.G.H.

Determination of density differences by flotation temperature method. MERLE RANDALL AND BRUCE LONGTIN. *Ind. Eng. Chem., Anal. Ed.*, **11** [1] 44–46 (1939).—A description of the construction and manipulative details of a flotation-temperature apparatus as used for analytical purposes is given. The development of the flotation temperature determination as a density micromethod is of particular interest. The flotation temperature can be determined to within 0.005°C in samples as small as 0.1 ml. A method of calculating densities and compositions from flotation temperatures is discussed, which includes a consideration of the thermal expansion of the float, changes of the temperature of flotation in the reference sample, and deviations from ideal solution laws. The design of a special slide rule for calculating the percentage composition from the flotation temperature is indicated. Illustrated. F.G.H.

Evaporation rate from moist surfaces. ANON. *Nat. Phys. Lab. Rept.*, **1937.**—The rate of evaporation is greatest when the moist surface faces the moving air. Higher rates than usual are obtained by increasing the turbulence of the air on the down-stream moistened surface when the latter is inclined to the stream of air. A.B.S.

Glass-blowing accessories. WALTER A. CARLSON. *Ind. Eng. Chem., Anal. Ed.*, **10** [11] 644–45 (1938).—Illustrated. F.G.H.

Glass-enclosed magnetic stirrer. J. H. SIMONS. *Ind. Eng. Chem., Anal. Ed.*, **10** [11] 638 (1938).—Details of construction are given. Illustrated. F.G.H.

Grinder for the manufacture of silicocalcareous materials. V. CHARRIN. *Céram., Verrerie, Email.*, **7** [1] 12–13 (1939).—The bar grinder, which has been used in

the U. S. since 1920 for grinding metallic minerals and coke, is now being applied in the grinding and mixing of materials with high moisture content. This type of grinder can not be used for ceramic powders which must not contain any metallic particles, *e.g.*, feldspar. The grinder is described. M.V.C.

Heat insulation. E. I. LLOYD. *Power & Works Engr.*, **32** [376] 268–71 (1937).—L. deals with heat losses in pipes and their reduction by insulation and describes the application of aluminum foil, glass silk, magnesia, kieselguhr, rock and slag wool, and buried piping. J.M.N.

Improved gas-analysis apparatus. C. M. BLAIR AND J. H. PURSE. *Ind. Eng. Chem., Anal. Ed.*, **11** [3] 166–68 (1939).—Details of construction and operation are given. Illustrated. F.G.H.

Keep leather belts healthy. J. A. WEBB. *Factory Management & Maintenance*, **97** [2] 76–78 (1939).—Chemical change causes the failure of 93% of all oak-tanned leather belting destroyed annually. Air rot is brought on by an increase in the acidity of leather as indicated by a drop below the normal p_H 3. Atmospheric influences cause this. A preservative solution will prevent the increase in acidity. Metal or alkali rot is due to particles of iron or other metals working into the fibers of the leather followed by a decrease in the leather acidity. No remedy is known for metal rot. Oil rot is caused by the action of mineral oil on the leather and can be cured by suitable belt dressing and removal of mineral oils and greases from the proximity of the belt. Dry rot, which is due to the removal of the normal fat content of the leather, is eliminated by the proper belt dressing. Illustrated. J.L.G.

Lovibond tintometer adapted by means of the Rothamstead device to measure colors on the C.I.E. system. R. K. SCHOFIELD. *Jour. Sci. Instruments*, **16** [3] 74–80 (1939).—The Rothamstead device is an obturator vane by which the observer, when matching a specimen by combining Lovibond glasses, can make the two surfaces under view appear equally bright. This greatly reduces the number of combinations required for color matching. Conversion graphs give the C.I.E. coördinates for these combinations in Standard Illuminant B. The C.I.E. coördinates of matched colors are thereby obtained. The structure and operation of the complete tintometer is described in detail. Illustrated. (C.I.E. is Commission Internationale de l'Eclairage or International Commission on Illumination.) See "Variation—," *Ceram. Abs.*, **15** [6] 172 (1936); "Nonelectrical—," *ibid.*, **18** [6] 161 (1939). J.L.G.

Modern methods in milling of industrial minerals. R. K. CARNOCHAN. *Trans. Can. Inst. Mining & Met.*, **42**, 29–34 (1939).—C. discusses the following methods: (*1*) *Crushing:* Nepheline syenite or feldspar for glass is crushed by a series of rolls and screened to remove 20-mesh material as it is produced. Glass sand is usually reduced by chaser mills fitted with outside revolving screens or vibrating screens to return unbroken aggregates to the mill. Rod mills followed by vibrating screens are now used in crushing sandstone. Hammer mills are used on relatively soft rocks. (*2*) *Grinding:* Uniform fineness and freedom from introduced iron are desired. The latter is obtained by using silex- or porcelain-lined mills with flint pebbles, porcelain balls, or silex blocks. The pebble mill in closed circuit with an air separator seems to be the best type. An electric ear is now being used to control feed to the pebble mill. (*3*) *Separating:* A new method of washing clay consists in using sodium silicate to disperse the clay and adding aluminum sulfate to the refined clay to coagulate it. Heavy-medium methods are being used to separate slate from coal and they may possibly be applied to industrial minerals; this also applies to heavy-chemical separation. Magnetic separation is being applied to nepheline syenite, feldspar, kyanite, sand, and quartz. Electrostatic separation is being tried on rutile and zircon. The air table is being used increasingly in purification, *e.g.*, in the case of mica. Flotation is applied to cement rock, phosphate, fluorite, and other minerals. Acid treatment is being used successfully for the removal of iron from glass sands. G.M.H.

Natural laws hurdle national boundaries. Z. C. KLINE. *Glass Ind.*, **19** [6] 227 (1938); *Ceram. Ind.*, **30** [6] 48–50 (1938).—After citing some of the natural laws which work the same in all parts of the earth, K. takes up the nature of light and shows how any rays below or above the visible octave are of no avail unless they can be converted into rays having the wave lengths found within the visible octave of light. The ability to convert the invisible ultraviolet rays into visible rays by allowing them to impinge on certain specially prepared chemical compounds has resulted in the development of the new fluorescent lamps known as lumiline lamps. See "Fluorescent—," *Ceram. Abs.*, **18** [4] 97 (1939). E.J.V.

Process for preparing and deairing raw clays. OTTO MANFRED. *Ber. Deut. Keram. Ges.*, **19** [7] 283–85 (1938).—M. gives suggestions for further technical development of the vacuum deairing process as the result of recent work on boundary surface phenomena in the study of colloids. Air attached or mechanically held by surface adsorption arrests or reduces the energy exchange which takes place mainly at the surface of the materials. An excessive degree of preparation by the usual methods may have the effect of reducing the bonding strength and packing density of certain clays. Such "short" clays are produced when there has been an excess of purely mechanical treatment, *e.g.*, in the edge runner mill. This phenomenon is also applicable to other materials; figures show that the strength of raw rubber and sheet zinc is considerably reduced by excessive treatment in the rolling mill. Attention should be given to the older methods of preparation whose efficiency depended on a cutting or grating action on the clay. The success of modern machines such as the clay slicer (Tonschnitzler), clay planer (Tonhobel), clay grater (Tonraspler, *Ceram. Abs.*, **18** [7] 191 (1939)), etc., is quoted in support of this view. Such machines, while exerting a stress-releasing action on the clay, give a sufficiently homogeneous mass without overtreating the clay. M. refers to the vacuum process in the manufacture of safety glass; here the press chamber is evacuated shortly before the actual pressing operation takes place. Similar considerations should be applied to the treatment of clays. See *ibid.*, **18** [6] 161 (1939). E.J.V.

Pumps for slurries and gritty fluids. ANON. *Fuel Economist*, **12** [140] 275–76 (1937).—The details of construction and operation of a rubber-lined pump are given. Illustrated. F.G.H.

Simplified combustion pipet. G. H. NELSON, H. D. WEIHE, AND D. F. J. LYNCH. *Ind. Eng. Chem., Anal. Ed.*, **11** [3] 169–70 (1939).—Details of construction and operation are given. Illustrated. F.G.H.

Simplified method of preparing microscopic glass spheres. KARL SOLLNER. *Ind. Eng. Chem., Anal. Ed.*, **11** [1] 48–49 (1939).—Details of preparation are described. Illustrated. F.G.H.

Spray gun in industry. CARLETON CLEVELAND. *Metal Ind.* [N. Y.], **37** [5] 221–24 (1939).—C. describes the history and technical development of industrial spray guns and spraying equipment and mentions many unusual applications. The importance of cleanliness is stressed. Seven illustrations, including two cutaway views of spray guns with all parts designated, are included. See *Ceram. Abs.*, **18** [5] 121 (1939). H.K.R.

Stainless forgings, metals. WALDEMAR NAUJOKS. *Metals & Alloys*, **10** [5] 144–50 (1939).—N. discusses the various ferrous and nonferrous metals and alloys suitable for manufacture into drop forgings which are noncorrosive. The stainless steels as well as the copper and nickel base alloys are reviewed in regard to their metallurgical and working properties. Illustrations of forgings made from such metals are included. J.J.H.

Temperature of liquid steel. G. W. C. KAYE. *Nat. Phys. Lab. Rept., 1938*, pp. 23–24.—A method developed for the measurement of the temperature of molten steel depends on the use of a platinum thermocouple of the quick immersion type which enables a reading of the temperature to be obtained in a few seconds. When lightly sheathed in silica, it will withstand immersion for 20 sec. in liquid steel at temperatures rising to a maximum of

1690°C. Though the silica softens, twelve successive immersions can be obtained with a single sheath at 1620°C without apparent depreciation of the thermocouple. The apparatus is mounted on a steel pipe 10 to 12 ft. long, clamped to a standard charging fork which is picked up by the furnace charger and inserted into the furnace. At the end of this pipe, another pipe (18 in. long) attached at right angles terminates in an orifice in which the silica sheath of the couple is wedged by packing with asbestos wool. All of the metal parts are encased in an insulating layer of light diatomite brick $1^1/_2$ in. thick. This packing prevents any noticeable rise in temperature inside the pipe and makes it possible to carry the compensating leads as far as the right-handed bend where union is made with the couple. The silica sheath, and occasionally the end block of diatomite, can be replaced in a few minutes at a small cost. The apparatus is now in regular use at steelworks in Sheffield and elsewhere. A.B.S.

Use of silica cotton in filter crucibles. W. Walker Russell and J. H. A. Harley, Jr. *Ind. Eng. Chem., Anal. Ed.*, **11** [3] 168 (1939).—Silica cotton is an ideal material for the filtering mats in Gooch crucibles. Upon ignition at 600°C, no change occurs in the silica cotton. F.G.H.

PATENTS

Air control for kiln-cooler assemblies. R. D. Cheesman (Traylor Engineering & Mfg. Co.). U. S. 2,160,956, June 6, 1939 (Aug. 3, 1938).—A method for insuring uniform heating conditions within a kiln of the rotary type.

Apparatus for the determination of moisture in ceramic and other materials. S. N. Makarin. Russ. 46,723, April 30, 1936; *Chem. Abs.*, **33**, 3214 (1939).—Construction details of an apparatus measuring the electrical resistance are given.

Apparatus for dipping objects. W. H. Kopitke (Plax Corp.). U. S. 2,159,091, May 23, 1939(Feb. 29, 1936).—A dipping machine comprises a series of traveling receptacles affording a series of individual pools containing coating medium into which bottle necks, etc., may be successively dipped, traveling article-carrying means movable with the pools, means for causing relative approach of successive article carriers and successive individual associated pools to successively submerge the article necks of articles carried by the carriers therein and for thereafter causing opposite relative movement so that the article necks are successively gradually withdrawn from submergence in the pools, and means including a tank and pumping means to circulate the coating medium successively and continuously from the tank to a pool back to the tank and then to another pool in succession.

Apparatus for the manufacture of articles from plastic materials. W. J. Miller. U. S. 2,160,484, May 30, 1939 (April 3, 1935).

Apparatus for the manufacture of pottery ware. W. J. Miller. U. S. 2,160,483, May 30, 1939 (April 3, 1935).

Apparatus for measuring charges of powdered and granulated materials. A. D. Paull (Wheeling Stamping Co.). U. S. 2,161,190, June 6, 1939 (Jan. 28, 1938).

Automatic control of grinding mills, etc. Hardinge Co., Inc. Brit. 505,177, May 17, 1939 (Nov. 11, 1936).

Elutriation classifier. Leonard A. Pinner. Can. 380,588, April 11, 1939 (March 15, 1937). G.M.H.

Filter-bag head. Louis A. Fitzgerald. Can. 380,271, March 21, 1939 (May 3, 1937). G.M.H.

Fusing borates. F. A. Beik. Brit. 504,870, May 17, 1939 (June 15, 1938).

Mounting or carrier for blades or knives for pugmills or other mixing apparatus. J. D. Thompson. U. S. 2,160,925, June 6, 1939 (Feb. 28, 1938).

Producing brick, tile, etc., from granular or powdered clay. F. Humphris. Brit. 505,652, June 1, 1939 (Sept. 21, 1938).

Producing granular material from ceramic masses. Oscar Sembach and Hans Navratiel (Sembach & Co. Komm.-Ges. vorm. Speckstein Steatit G.m.b.H.). Ger. 671,602, Jan. 26, 1939(Aug. 6, 1937); VI/80*b*. 12.15.—In a method for producing granular material from ceramic masses which is to be pressed into forms, filter-cake masses are drawn into thin strands in a deairing wire cutting press, dried, pulverized, and sifted. D.A.B.

Sedimentation apparatus. L. D. Goodhue and C. M. Smith (dedicated to the free use of the people in the territory of the United States). U. S. 2,163,000, June 20, 1939 (June 14, 1938).—A differential manometer-type sedimentation apparatus comprises a lower sedimentation tube, a narrower upper tube disposed on top of and communicating with the sedimentation tube, an outlet tube near the junction of the upper and lower tubes, an indicator tube disposed parallel to the upper and lower tubes, a tapered capillary tube connecting the indicator tube to the lower tube at a point above its bottom, a cross tube connecting the indicator tube to the upper tube at a point below its top, a stopcock disposed between the cross tube and the indicator tube, and a glass-enclosed scale disposed on the indicator tube.

Tunnel drier for ceramic ware. E. P. Bratkova. Russ. 47,936, July 31, 1936; *Chem. Abs.*, **33**, 3553 (1939).—Construction details are given.

Kilns, Furnaces, Fuels, and Combustion

Design and firing of kilns: XVI. Anon. *Brit. Clayworker*, **48** [565] 38–40 (1939).—The Monnier, Harrop, and Möller and Pfeifer tunnel kilns and cars are described. For Parts **XIV–XV** see *Ceram. Abs.*, **18** [7] 193 (1939). R.A.H.

Electric heat in the ceramic industry. E. M. Ackery. *Elec. Times*, **94** [2443] 211–12 (1938).—Nickel-chromium resistances can not be used as furnace elements for biscuit firing which requires temperatures from 1250° to 1400°C; even such new materials as iron-chromium-aluminum alloys are liable to brittleness and growth in use. A few electrically-heated kilns are nevertheless in use in Britain and Europe. It is often necessary to use nonmetallic resistances for glost firing, although the temperatures do not exceed 1150°C, because of attack by the glaze. Electric kilns are the most suitable for enamel firing and allow control of both temperature and furnace atmosphere. Small electric-heated kilns are especially suitable for private potteries, schools, and small works. J.C.C.

Examining the performance of pulverized coal burners. A. G. Arend. *Fuel Economist*, **12** [136] 137–38 (1937).—A. describes the application of motion photomicrography in examining the combustion processes in pulverized fuel fired chambers. F.G.H.

Even and uniform ceramic firing with luminous gas flames. Eugene Hardesty. *Ceram. Ind.*, **31** [5] 34–35 (1938).—The introduction of gas firing has resulted in more economical operation, as a larger number of commercially salable pieces per kiln are obtained. Some of the ware fired with coal or wood has been of higher quality than that obtained with gas firing. The ideal ceramic firing would give the quality possible with coal firing without the attendant rejections and would have the economies and ease of control possible with gas. An analysis of applications of the two fuels is made, and it is evident that, if luminous flames could be obtained without the use of a reducing atmosphere, the advantages of coal firing would accrue. Using a Universal burner capable of producing either clear or luminous flames at will, a glost kiln was converted to luminous flame firing. Radiant heat was carried well into the load, resulting in good temperature distribution and penetration through the ware with easy control of the furnace atmosphere due to the consistent maintenance of the air-gas ratio as set. E.J.V.

Factors in economical grinding and pulverizing. Anon. *Fuel Economist*, **11** [132] 452–56 (1936).—Factors affecting the selection and operation of equipment for the grinding

and pulverizing of coal are discussed in detail. Illustrated. F.G.H.

Industrial gas and the competitive angle. RAYMOND F. MANN. *Amer. Gas Jour.*, **150** [4] 19–22 (1939).—M. discusses the advantages of gas over such fuels as coal, coke, and the various types of fuel oils in the firing of industrial furnaces. Particular stress is placed on such features as convenience in handling, necessity of small combustion spaces, and ease in controlling the rate of combustion. M. points out the severe action of fuel oils upon the refractories, citing an example of a forge furnace in which the refractories gave three weeks' service when using oil as compared to six months with gas. The cheaper initial cost of fuel oil is partially offset by the added maintenance costs in regard to the motors, pumps, blowers, and clogging of burners due to carbon. B.C.R.

Kilns *versus* ovens for temperatures of 960° to 980°C. H. HOPE. *Trans. Brit. Ceram. Soc.*, **38** [4] 281–83 (1939). —H. compares the practice and results obtained in one plant. R.A.H.

Measurement of plastic properties of bituminous coals. R. E. BREWER AND J. E. TRIFF. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 242–47 (1939).—A modified Gieseler plastometer and test procedure have been developed. Plasticity data obtained by this method are compared with data found by the Agde-Damm dilatometer and Davis plastometer methods. Considering the differences in operating characteristics of the three instruments, good agreement is shown on typical temperature points and on degrees of fluidity. Illustrated. See *Ceram. Abs.*, **16** [3] 96 (1937). F.G.H.

Performance characteristics of natural draft chimneys. J. G. MINGLE. *Power Plant Eng.*, **43** [4] 245 (1939).—M. discusses ways of determining the proper size chimney necessary to remove a given volume of gases. The output of inadequately sized chimneys can be increased by increasing either the flue temperature or the height of the stack; stacks with a high height to diameter ratio can not be increased as much as those with a smaller ratio. B.C.R.

Piping flow conditions of industrial fuel oil. E. G. ROBERTS. *Power Plant Eng.*, **43** [4] 252 (1939)—R. gives the formula and data, with an example calculation, necessary to determine the pressure in oil lines. B.C.R.

Problems encountered in evaluating the performance and efficiency of kilns with special reference to the heavy clay industry. E. ROWDEN AND A. T. GREEN. *Trans. Brit. Ceram. Soc.*, **38** [3] 173–210 (1939).—Details are given for testing of the efficiency of kilns of the intermittent and continuous types. R.A.H.

Recirculating air heating for industrial furnaces. E. STEPHENSON, JR. *Ind. Heating*, **6** [4] 316–20; [5] 408–12, 420 (1939).—S. reviews the principles involved, advantages obtained, burner arrangement, combustion and temperature control, safety arrangements to prevent formation of explosive mixtures in the furnace, and constructive features. Practical examples are given. M.H.

Submerged heat. SUBMERGED COMBUSTION CO. *Steel*, **103** [15] 84, 86, 103 (1938).—Newly perfected gas burners, lighted and controlled automatically, produce notable economies in heating of pickling baths. The burner plate is located 4 or 5 in. beneath the solution level. It directs the flame through a tubular combustion chamber which conducts the products of combustion down to and across the tube bottom where the products of combustion may be vented and distributed to give the desired agitation. The advantages of its use in pickling steel are decrease in pickling time, more uniform temperature in bath hence more uniform pickling, increased agitation, increased flexibility, saving in labor costs, and evaporation of water; the solution is therefore not diluted as is the case when steam condenses in the solution. The burner has many other adaptations for solution heating. H.E.S.

Versatility of the traveling grate stoker. ANON. *Fuel Economist*, **12** [139] 239–44 (1937).—The development of the modern traveling grate stoker and its application to various purposes and use with various fuels are described. Illustrated. F.G.H.

PATENTS

Charging attachment for feeding holes of brickyard ovens, etc. HEIN & HEIN. Ger. 672,894, Feb. 23, 1939 (Aug. 20, 1936); V/80*c*. 16.01.—The mechanical details of a charging attachment are given. D.A.B.

Electric heating resistors of bar form. SIEMENS-PLANIAWERKE AKT.-GES. FÜR KOHLEFABRIKATE. Brit. 505,531, May 24, 1939 (Nov. 20, 1937).

Tunnel-kiln construction and method of operation. P. D'H. DRESSLER (Swindell-Dressler Corp.). U. S. 2,159,965, May 30, 1939 (July 17, 1937).

Geology

Bauxite; waste in exploitation of deposits. V. CHARRIN. *Argile*, No. 193, pp. 1–7 (1939).—Deposits of high quality bauxite are not as abundant in the world as is generally believed. French bauxite deposits are being wastefully depleted. Since the World War, U. S. deposits have been the principal source of bauxite. Only a more methodic exploitation will prevent the premature exhaustion of French bauxite, which surpasses in quality all bauxites of the Mediterranean basin. See *Ceram. Abs.*, **16** [3] 97 (1937); "World—," *ibid.*, **17** [7] 263 (1938). M.V.C.

Bentonite and insulating materials. V. C. *Verre & Silicates Ind.*, **10** [8] 92–93 (1939).—The properties of bentonite are briefly given. M.V.C.

Ceramic materials in India. ANON. *Times Trade & Eng.*, **44**, 2, 9, 23, 26 (1939).—Large bauxite deposits occur in the Western Ghats. The discovery of a large layer of china clay, perhaps the largest in India, at a village on the Travancore coast, about ten miles from Quilon, led to the starting of a ceramic factory under Government auspices which seems likely to revolutionize the ceramic industry in India. The deposits are of the best quality of china clay and will last for centuries. A washing plant, as well as machinery for the manufacture of porcelain insulators, sanitary ware, and drainage and household stoneware, has been installed. Washed china clay is also sold for the sizing of textile fabrics, paper, etc. Small quantities of sillimanite have recently been isolated from sand dunes along the Travancore coast. Mica occurs in several parts of the State. Pottery is made in many parts of India but specially in Travancore, Jammu, Kashmir, and Gwalior. In the latter State, the works of the Gwalior Potteries, Ltd., are fully equipped for the manufacture of crockeryware, tile, flooring, sanitary requisites, drain pipe, toys, jars, firebrick, and insulators. The clay fields owned by the factory yield some of the best kaolin, and the goods manufactured are superior in quality to and more durable than those made in other parts of India. The factories show little profit, however, owing to the keen competition of imported cheap Japanese goods. A cement works capable of producing 100 tons of cement a day is being constructed at Malla Pahar in Patiala. The output of the cement works at Dwarka, Baroda, was 81,840 tons in 1937–38. It is one of the largest cement works in India. A.B.S.

Chemists find way to use low-grade Italian bauxite. ANON. *Science News Letter*, **34** [20] 317 (1938).—Investigators at Columbia University report that aluminum can now be obtained from low-grade ferruginous bauxites. The process of preparation consists in treating bauxites with an excess of sulfur at high temperatures to form sulfides of iron, titania, and silica. These sulfides are then treated with an excess of chlorine, and aluminum chloride results. The treatment of an Italian bauxite at 600°C removed 90% of the iron oxide, 50% of the titania, and

14% of the silica, with a loss of 9% of the alumina. The cost of treatment may be too high at present, but in case of war it would not be objectionable. P.G.H.

Clay of decalcification, laterite, and bauxite. V. CHARRIN. *Céram., Verrerie, Email.*, **7** [3] 99–100 (1939).—Unlike most clays which are derived from the alteration of feldspars, clay of decalcification or *terra rosa* is derived from calcareous matrix rock through the dissolving action of atmospheric agents. Of the products which result, clay and iron oxide are deposited while carbonic acid is given off and the lime is carried away by the dissolving waters. This clay abounds in limestone beds and caves. It can be used for brick and tile. Red clay from a cave in the valley of the Vidourle at Vic-le-Fesq (Hérault, France) contained 60% silica, 16% alumina, 11% iron sesquioxides, and 14% water; there was no trace of lime, although the limestone cave was so situated that the clay could only have been formed from the surrounding limestone. This proves that whitish calcareous rock can give rise to clay deposits with high iron oxide content. This phenomenon in a temperate climate remotely resembles laterization in the tropics where heat and dampness produced immense laterite formations (laterite, because of the color, is derived from the word *later* meaning brick). Laterite is an unstable rock low in silica, lime, magnesia, and alkalis, with a tendency toward aluminum hydrates and iron. Extreme laterization would result in bauxite. This hypothesis would explain the peculiarities of bauxite. According to de Lapparent (*Ceram. Abs.*, **17** [10] 339 (1938)), bauxite is an eluvial formation which resulted from the evolution of clays of decalcification. Only European bauxites rest on calcareous rock and have had to pass through the decalcification stage before reaching that of laterization, which may account for their particular structure and lower water content. According to C., the name bauxite should be given only to those laterite products derived from limestone in order to differentiate them from other laterites which may sometimes have a higher alumina content. See *ibid.*, **18** [1] 33 (1939). M.V.C.

Domestic kaolin or china clay sales in 1938. ANON. *Bull. Amer. Ceram. Soc.*, **18** [6] 233 (1939).

Economic resources and possibilities of ceramic materials in India. FRANK BROWN. *Times Trade & Eng.*, **44**, 20, 23 (1939).—The kaolin deposits of Travancore are rich, and it is hoped that the making of china clay and porcelain products will soon be one of the recognized and prosperous industries. There are also large deposits of monazite, ilmenite, and graphite, but neither coal nor mineral oil is obtainable. In Bhopal, there are large undeveloped deposits of bauxite. There is a large pottery works in Gwalior. A.B.S.

Electrical charges on clay particles. R. K. SCHOFIELD. *Soils & Fertilizers*, **2** [1] 1–5 (1939); *Chem. Abs.*, **33**, 3507 (1939).—With clays of the montmorillonite, kaolinite, and halloysite groups the electrical charges on the particles remain substantially constant from p_H 6 downward, but there are other clays (not yet mineralogically identified) for which this is not true. These latter are distinguished by their ability to absorb chloride from HCl solution. Their behavior toward alcoholic HCl is particularly striking, as practically the same amount of chloride is taken up from solutions covering a wide range of concentration. The adsorption from aqueous acid is less but increases with concentration. It appears certain that at low p_H values these clays carry positive charges. See "Physical—," *Ceram. Abs.*, **18** [1] 34 (1939).

Fillers—clay, talc, etc., 1918–1938. T. POOLE MAYNARD. *Chem. Industries*, **43** [6] 491–95 (1938).—M. discusses the uses and purification of such fillers as china clay, talc, bentonite, whiting, and wood flour. P.G.H.

Fresh-water diatomite in the Pacific coast region. HENRY MULRYAN. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1057; *Mining Tech.*, **3** [3] 8 pp. (1939).—These deposits are in California, Nevada, Utah, Idaho, Oregon, and Washington and are generally associated with volcanic activity of late Tertiary or Pleistocene time. Lakes were formed by the damming of streams by lava flows. In many cases later flows covered the deposits, although in a few places the lakes still exist and diatoms are still being deposited. One deposit has large diatoms from which filter aids are produced. The rest are mainly small diatoms, used for polishes, fillers, admixtures, and insulation products. W.D.F.

Geologic basis from the ceramic viewpoint of the Sudeten area. C. MICHLER. *Ber. Deut. Keram. Ges.*, **20** [2] 93–99 (1939).—Geologic resources in the Sudeten area such as brown coal, mineral waters, kaolin, and clay are discussed. Of primary importance are the kaolin deposits of Karlsbad-Elbogen. Illustrated. C.H.R.

Geology of Quebec. THÉO. C. DENIS AND JOHN A. DRESSER. *Can. Mining & Met. Bull.*, No. 322, pp. 51–52 (1939).—The Quebec Bureau of Mines plans to gather all present known geological description into a single comprehensive work. G.M.H.

Ilmenite-hematite-magnetite relations in emery ores. J. M. BRAY. *Amer. Mineralogist*, **24**, 162–70 (1939).—The principal mode of occurrence of hematite and ilmenite in emery ores from a number of localities is in the form of unique exsolution intergrowths, suggesting unusual crystallization-temperature-solution conditions. Magnetite, which is not a component of these exsolution intergrowths, is the most abundant opaque constituent in some polished sections, but it is rare or totally absent in others. Ilmenite exsolves from hematite to sharp magnetite-hematite boundaries, showing that much of the hematite now present crystallized originally as hematite, and is thus not a later replacement product of magnetite. Some replacement of magnetite by hematite is noted, but only a minor percentage of the total hematite present has formed in this manner. Ilmenite of one age often exsolves parallel to two crystallographic directions within hematite. In addition, two readily distinguishable ages of exsolution ilmenite in hematite are often observed. The ilmenite bodies of each age have a characteristic orientation in the hematite. The original solid solution varied in composition from dominant hematite to dominant ilmenite. Exsolution of hematite from corundum is well shown in some sections. In those ores in which corundum exhibits parting, hematite exsolved both as blebs and as needles; in the ores in which corundum does not exhibit parting, hematite exsolved only as minute blebs. F.J.Z.

Industrial minerals in British Columbia. J. M. CUMMINGS. *Can. Mining & Met. Bull.*, No. 319, pp. 552–66 (1938).—C. reviews the present situation of the nonmetallic mineral industries. There is little room for further development of the structural clay or common fireclay products industry, but there is room for expansion in special refractories and other clay products and an opportunity for the development of a mineral wool industry and a bentonite industry. G.M.H.

Kaolin mining in the Sudetenland and Austria and its importance for German mining economics. F. KIRNBAUER. *Berg- & Hüttenmänn. Monatshefte Montan. Hochschule Leoben*, **87** [4] 73–83 (1939).—Geographical and geological conditions of the kaolin deposits are described; Zettlitz kaolin, one of the most famous because of its purity, was formed (in the Karlsbad district) by transformation of granite in the upper Oligocene period. Statistics on production, export, and exploiting companies are given, and the importance of this industry in the German financial system is discussed. 17 references. See "Productive—," *Ceram. Abs.*, **17** [5] 197 (1938). M.H.

Kieselguhrs of Touraine. V. CHARRIN. *Argile*, No. 191, pp. 1–5 (1939).—The resources of kieselguhr which could be industrially exploited in France have been considered very limited until the present time when a study of the vast geological formations of Touraine, which are composed of pure clays, pure siliceous earths, and mixtures, revealed the presence of large deposits of very pure kieselguhr. It is white and has no plasticity or cohesion such as clays possess. The apparent density of a block varies between 0.75 and 0.85; it is easily ground and the density becomes as low as 0.50. Lime is entirely absent but there is a high silica content. With rational exploitation these deposits could supply the entire French market. Their

most important application is in the manufacture of refractory materials, mortars, and cements. M.V.C.

Methods for clay mineral analysis. W. NOLL. *Ber. Deut. Keram. Ges.*, **20** [4] 180–200 (1939).—Such methods as (1) mechanical analysis (preparation of samples and fractionation), (2) optical analysis, (3) X-ray methods, (4) thermal methods (thermic dissociation, thermochemical effect), and (5) chemical methods (analysis, base-exchange, and colorimetric) are discussed in detail. C.H.R.

Mineral resources and productivity. A. M. HERON. *Times Trade & Eng.*, **44**, 58 (1939).—In the great alluvial plains of the Indus and the Ganges rivers, deposits of sand and clay several thousand feet thick provide by far the most widely used building material in India (sun-dried or fired brick). The Himalaya mountains are remarkably poor in workable deposits of useful minerals but yield a little oil and some chrome. India produces three fourths of the world's production of sheet and block mica. The mica belt of Bihar is 60 miles long and 12 to 14 miles wide and runs in a general east and west direction along the junctions of the Gaya, Hazaribagh, and Monghyr districts. Ilmenite occurs with monazite and zircon in the black sands of the beaches near the southernmost point of India. The output of zircon was 1329 tons in 1937. Chromite is mined in Baluchistan, Mysore, and the Singhbhum district of Bihar. Chromite brick are made in India for furnace linings for steelworks. The remainder of the chromite is exported to the U. S., Germany, and the United Kingdom. Excellent fire-clay and silica brick are made in India for domestic use. India also exports considerable magnesite and kyanite. The amount of magnesite is virtually unlimited; it forms hillocks rising 140 ft. above the plain which are suitable for easy quarrying. The output in 1937 was 26,166 tons, almost twice that of 1936. Kyanite is mined in Singhbhum, Bihar, and Kharsawan State, partly for use in India as furnace linings and partly for export; 29,321 tons were mined in 1937. Deposits of mixed sillimanite and corundum occur in the Shillong plateau, Assam, and at Pipra in Rewah State, Central India, but they have not been mined in recent years. A.B.S.

New source of feldspar in Canada. ANON. *Stone*, **60** [2] 77 (1939).—A new feldspar claim has been staked near William, Ontario, on Lake Superior. The material analyzes 10.61% K_2O and 0.70% Na_2O, is white in appearance, and is mixed with little or no quartz. P.G.H.

Report of Committee on Geological Surveys: Clay definitions. H. RIES, Chairman. *Bull. Amer. Ceram. Soc.*, **18** [6] 213–15 (1939).

Serpentine. C. MORE. *Argile*, No. 192, pp. 7–13 (1939). Serpentine, $H_4Mg_3Si_2O_9$, or ophiolite of Brongniart is a complex rock composed of hydration products of olivine, pyroxene, or amphibole. These minerals are hydrated magnesium silicates. There are many varieties, and the name serpentine is derived from their mottled appearance which resembles snakeskin. In color it is green, yellow-green, brown, and white when pulverized. It has a resinous luster and conchoidal uneven fracture; the density is 2.47 to 2.6 and the hardness is 3 to 4. It is hard to fuse with a blowpipe and becomes white with loss of water. Serpentine may be (1) uniform, (2) veined, (3) porphyroid, (4) globiferous, (5) garnet containing, (6) of asbestos form, (7) pseudofragmentary, (8) noble, or (9) Aker serpentine. The mineralogical classification (*Ceram. Abs.*, **17** [9] 313 (1938)) is given and discussed. Serpentine deposits in France are listed. Because of its magnesia content, serpentine is a possible source of magnesia for refractories. A bibliography is given. M.V.C.

Ultramicroscopic examination of clay minerals. W. EITEL, H. O. MÜLLER, AND O. E. RADCZEWSKI. *Ber. Deut. Keram. Ges.*, **20** [4] 165–80 (1939).—An ultramicroscope using the principle of the two-stage magnetic electron microscope was used to obtain photomicrographs not possible with the ordinary optical microscope. Various clay minerals found in Zettlitz kaolin, pholerite, and a synthetic kaolin were studied. Samples were studied at room temperature, 450°C, 500°C, and in stages of 100°C thereafter to 1200°C. With increased temperature, the edges of the minerals began to crumble until, at 800°C, a fine powder was obtained. With increased temperature recrystallization took place resulting in increases in grain size. The temperature of the characteristic changes was greater for Zettlitz kaolin than for the synthetic kaolin or pholerite. The results lead to considerations of the ultimate particle in clay. Photomicrographs and a bibliography are presented. C.H.R.

SEPARATE PUBLICATION

Electrometallurgical investigations: Metallurgical Division Progress Report No. 30, Recovery of potassium sulfate and alumina from alunite by fusion with boric acid. J. KOSTER, R. G. KNICKERBOCKER, A. L. FOX, AND P. R. PERRY. *U. S. Bur. Mines Repts. Investigations*, No. 3438, 15 pp. Free. A process for the recovery of potash and alumina from alunite ores is described in detail. R.A.H.

Chemistry and Physics

Chemical microscopy. CLYDE W. MASON. *Crucible*, **23**, 122 (1939).—Various phenomena of physical chemistry are illustrated microscopically, including solid solution, eutectics, crystallization, and allotropic change. W.D.F.

Colorimetric determination of manganese with periodate. Spectrophotometric study. J. P. MEHLIG. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 274–77 (1939).—A spectrophotometric study shows that the periodate method for the colorimetric determination of manganese is satisfactory with very few limitations. M. studied the effect of fifty-six common ions. A few seriously interfere with the color, but in the course of the determination, most of these would be removed. Illustrated. F.G.H.

Critical and coöperative phenomena: III, Theory of melting and structure of liquids. J. E. LENNARD-JONES AND A. F. DEVONSHIRE. *Proc. Roy. Soc.* [London], **A169**, 317–38 (1939).—The authors attempt to construct a theory for the melting of solids based on a picture of disorder in the resulting liquid. A.P.

Determination of fluorine. D. S. REYNOLDS AND W. L. HILL. *Ind. Eng. Chem., Anal. Ed.*, **11** [1] 21–27 (1939).—Several factors that cause interference in the determination of fluorine were studied by distilling the sample with perchloric, phosphoric, or sulfuric acid and titrating the distilled fluorine with thorium solution. The titration is markedly affected by orthophosphate, sulfate, and hypochlorite ions and is affected to a much less extent by alkali, borate, and sulfide ions. In the concentration range studied, arsenite, chlorate, and silicate ions have no observable effect. Interference is greatly reduced and a sharper end point is obtained when the titration medium is an aqueous instead of an alcoholic solution. Difficulties arise from substances such as (1) aluminum compounds and gelatinous silica, which retard the distillation of fluorine, and (2) the distilling acid, phosphate, pyritic sulfur, organic materials, and halogens other than fluorine, which are incompletely separated from the fluorine and cause trouble in the subsequent titration. When perchloric acid is used as the distilling acid, the distillates of most types of phosphate rocks studied carry negligible quantities of perchlorate and phosphate. The separation of fluorine from pyritic sulfur and organic matter is improved by distilling the sample in the presence of excess permanganate. Illustrated. F.G.H.

Determination of rhenium. Estimation in pyrolusite. LOREN C. HURD AND CLARENCE F. HISKEY. *Ind. Eng. Chem., Anal. Ed.*, **10** [11] 623–26 (1938).—An analytical method for the determination of rhenium in the presence of large amounts of manganese dioxide has been developed and demonstrated on synthetic mixtures. Analysis of

a representative group of pyrolusite samples from many parts of the world indicated that the naturally occurring mineral contains inappreciable amounts of rhenium. The highest concentration observed was 0.2 part per million parts of mineral. Illustrated. F.G.H.

Hydrocompounds of nickel and magnesium silicate minerals. K. SPANGENBERG. *Naturwissenschaften*, **26** [35] 578–79 (1938).—X-ray and chemical constants for pimelite [$3(Ni,Mg)O \cdot 4SiO_2 \cdot H_2O + xH_2O$], garnierite [$3(Ni,Mg)O \cdot 2SiO_2 \cdot 2H_2O$], and schuchardite, an isomorphic mixture of Ni-antigorite [$3(Ni,Mg)O \cdot 2SiO_2 \cdot 2H_2O$] and Ni-amesite [$2(Ni,Mg)O \cdot (Al,Fe^{III})_2O_3 \cdot SiO_2 \cdot 2H_2O$], are given. C.H.R.

p-Hydroxyphenylarsonic acid as a reagent for titanium and zirconium. C. T. SIMPSON AND G. C. CHANDLEE. *Ind. Eng. Chem., Anal. Ed.*, **10** [11] 642–43 (1938).—*p*-Hydroxyphenylarsonic acid is an advantageous reagent for separating titanium from ions of ferric, ferrous, aluminum, zinc, cobalt, nickel, beryllium, chromic, manganous, calcium, magnesium, thallium, cerous, thorium, sodium, potassium, and ammonium, as well as phosphate, molybdate, chromate, vanadate, permanganate, uranyl, and vanadyl. Interfering ions are zirconium, cerium(ic), and tin. Hydrogen peroxide also must be absent. The reagent may be used to determine zirconium in the presence of the above ions. Phosphate in more than very small amounts interferes. Zirconium may be separated from titanium if hydrogen peroxide is present. Cerium(ic) and tin interfere. The use of the reagent in the analysis of clays and fired refractories is described in detail. F.G.H.

Iron determination in presence of titanium using zinc reduction. EMIL TRUOG AND R. W. PEARSON. *Ind. Eng. Chem., Anal. Ed.*, **10** [11] 631–32 (1938).—In agreement with the results of previous workers, interference by titanium in the oxidimetric titration procedure for iron, involving the use of amalgamated zinc for reduction, can easily be eliminated by aeration immediately after reduction so as to reoxidize the titanium selectively. This selective oxidation by aeration after passage of the solution through a Jones reductor is effected more conveniently and expeditiously by adding a little aerated water and stirring for a few minutes than by aspiration. F.G.H.

Measuring the transmission of radiant heat energy through electric nonconductors. E. ECKERT. *Forsch. Gebiete Ingenieurw.*, **9** [5] 251–53 (1938).—E. gives data for glass, mica, paper, and salt. Data for glass are found by using one to five layers of 0.16 mm. thickness each and checking the result against solid glass of 0.96 mm. Transparent mica 0.42 mm. thick, sliced down in steps to 0.01 mm., and black mica 0.12 mm. and 0.35 mm. thick were used. Both resulted in one identical curve. Salt had a permeability of 70 to 74% with thicknesses between 2 and 50 mm. Radiation with wave lengths below 16 microns is not reduced, while radiation with wave lengths above 16 microns is completely absorbed. See "Distribution—," *Ceram. Abs.*, **15** [8] 253 (1936). J.M.N.

Methods of obtaining precipitated silica. L. M. FRIDBERG. *Caoutchouc & Rubber* [U.S.S.R.], **1939**, 82–83; *Chem. Abs.*, **33**, 3975 (1939).—Precipitated SiO_2 makes a good reinforcing filler. It is made as follows: (1) precipitation of Na_2SiO_3 with CO_2; (2) the use of HF and SiF_4, which are by-products in the superphosphate industry, $4HF + SiO_2 \rightarrow SiF_4 + 2H_2O$, and decomposition of the SiF_4 with H_2O; (3) decomposition of H_2SiF_6 with NH_4OH and precipitation of SiO_2; and (4) decomposition of Na_2SiF_6 with Na_2CO_3 and precipitation of SiO_2.

Microdetermination of fluorine by thorium nitrate titration. F. J. MCCLURE. *Ind. Eng. Chem., Anal. Ed.*, **11** [3] 171–73 (1939).—The microdetermination of fluorine by titration in aqueous solution with thorium nitrate according to Armstrong's latest technique did not give the high degree of accuracy obtained by Armstrong. The recovery of fluoride added to bone ash in 50- to 100-microgram quantities varied about ±5 micrograms from the total added. Duplicate samples of bone and tooth ash agreed within 2 to 6 micrograms of the total fluorine, where a total of 50 to 100 micrograms of fluorine was determined, the size sample equaling not more than 0.5 g. of ash. The necessity of avoiding glass or porcelain containers in evaporation of alkaline fluoride distillates, previous to titration with thorium nitrate, is indicated. Prevention of volatilization of chloride by preciptation with silver sulfate added to the distilling flask was satisfactory. F.G.H.

Photoelectric methods in analytical chemistry. RALPH H. MÜLLER. *Ind. Eng. Chem., Anal. Ed.*, **11** [1] 1–17 (1939).—An extensive bibliography is included. Illustrated. F.G.H.

Qualitative separation on a microscale. Analysis of the tellurium and copper groups of A. A. Noyes and W. C. Bray. BERL S. ALSTODT AND A. A. BENEDETTI-PICHLER. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 294–98 (1939).—A milligram procedure is presented for the analysis of the tellurium and copper groups of A. A. Noyes and W. C. Bray. The scheme provides for the isolation, estimation, and confirmation of 10 micrograms of any member of the groups in the presence of 500 micrograms of any other member. The essential features of the scheme of Noyes and Bray are retained. Rhodium is precipitated as metallic rhodium by titanous chloride, redissolved, and confirmed by the red coloration obtained with stannous chloride. Molybdenum is identified by the blue coloration of the residue of the ether extract, the red coloration produced by potassium thiocyanate, and the precipitation of the black sulfide. The presence of other elements of the two groups is confirmed by slide tests. Examples show the applicability of the procedure. F.G.H.

Radioactivity of glass, porcelain, and mica. S. GAWROŃSKI. *Acta Phys. Polon.*, **7**, 253–71 (1938); *Chem. Abs.*, **33**, 3256 (1939).—G. states that these materials used for construction of Geiger-Müller counters are sources of inhomogeneous β and γ radiation. This radiation is caused by the presence of radioactive elements either as components of the materials investigated or as impurities. For determining the intensity of radiation, counter tubes of brass gauze on thin brass foil (0.031 mm. thickness) were used.

Rapid potentiometric determination of zinc. D. G. STURGES. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 267–68 (1939).—The volumetric determination of zinc, by adding an excess of potassium ferrocyanide and potentiometrically back-titrating the excess with ceric sulfate, using a platinum-tungsten electrode pair, can be carried out with a precision equivalent in magnitude to methods employing external or internal indicators. Illustrated. F.G.H.

Separation and determination of aluminum and beryllium using tannin. M. L. NICHOLS AND JOHN M. SCHEMPF. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 278–80 (1939).—Moser and Niessner's method for the separation and determination of aluminum and beryllium using tannin gives satisfactory results with careful regulation of the p_H of the solution and time of digestion. F.G.H.

Separation and determination of copper and nickel by salicylaldoxime. L. P. BIEFELD AND D. E. HOWE. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 251–53 (1939).—Hydrogen-ion concentration is an important factor in the use of salicylaldoxime as an analytical reagent. Copper salicylaldoxime complex starts to precipitate from pure solutions in quantitative amounts at a p_H of 2.6. Nickel salicylaldoxime complex starts to precipitate from pure solutions at a p_H of 3.3. The amount is quantitative at a p_H of 7.0. The p_H range of separation of copper from nickel by the use of the reagent is 2.6 to 3.1. This range is not appreciably different from that predicted by results obtained with pure solutions. Very little entrainment of the nickel complex by the copper complex was found. The presence of the copper precipitate does not appreciably affect the solubility of the nickel complex. Entrainment of the iron complex occurs over the entire range of hydrogen-ion concentration studied. It is not due to adsorption alone. The amount decreases with increase of p_H. Salicylaldoxime affords a rapid, simple, accurate, and fairly cheap method for the separation and determination of copper and nickel in various mixtures. Illustrated. F.G.H.

Structure analysis of libethenite, $Cu_2(OH)(PO_4)$. H.

HERITSCH. *Naturwissenschaften*, **26** [32] 529 (1938).—H. shows that libethenite has parameters similar to those of olivinite and andalusite. C.H.R.

Studies of chemical structure by means of Fourier analysis: II. H. G. GRIMM, R. BRILL, C. HERMANN, AND C. PETERS. *Naturwissenschaften*, **26** [29] 479–80 (1938).—The presence of two conducting electrons in magnesium was proved. Illustrated. C.H.R.

Tetraphenylarsonium chloride as an analytical reagent. HOBART H. WILLARD AND GEORGE M. SMITH. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 269–74 (1939).—The use of this reagent in the determination of mercury, tin, cadmium, and zinc is described in detail. F.G.H.

Volumetric determination of aluminum using sodium citrate. ALBERT C. TITUS AND MELVIN C. CANNON. *Ind. Eng. Chem., Anal. Ed.*, **11** [3] 137–40 (1939).—While sodium citrate is an essential reagent in an excellent volumetric aluminum method developed long ago and is also used in a more recent cold method, the authors were not satisfied that equilibrium was attained quickly enough without heating. Their method involves a correction for any free acid and the cold titration of the acid liberated from a previously heated mixture of sodium citrate solution with the unknown aluminum solution. The calculation of the aluminum content is based on substitution in an appropriate equation of the amount of sodium hydroxide used in titrating the liberated acid. The method is applicable to solutions which are free from appreciable quantities of iron or other interfering ions. F.G.H.

BOOK

Crystal Chemistry. C. W. STILLWELL. McGraw-Hill, New York. 431 pp. Price $4.50. Reviewed in *Jour. Chem. Education*, **16** [4] 197 (1939).—S. intends this book to be a combination of elementary text and a starting point for further study. He deals with the sizes of atoms and ions, the nature of the metallic state, the structures and properties of alloys, the structure of compounds, and the fiber state. It is a noteworthy summary of the literature on the chemical side of crystal structure. P.G.H.

PATENTS

Extraction of alkali hydrates or carbonates and of aluminum hydroxide from the double silicates of alkali and alumina. R. S. OPATOWSKI AND PIERO ADAMOLI. U. S. 2,163,466, June 20, 1939(June 2, 1937).—A process for the extraction of potassium carbonate and aluminum hydroxide from leucite comprises pulverizing the leucite, adding thereto for each 100 parts by weight of leucite with a K_2O content of 18% about 250 parts of limestone and 25 parts of fluorite, both finely pulverized, and intimately mixing the materials, calcining the materials in a kiln for 1 hr. and 30 min. at 930°C, extracting the calcined materials from the kiln, separating the potassium aluminate from the insoluble residue by lixiviating the calcined materials with hot water at atmospheric pressure, treating the potassium aluminate solution with carbon dioxide, separating the precipitated aluminum hydroxide from the mother liquor, and evaporating the latter to obtain solid potassium carbonate.

Making sodium aluminate. R. L. DAVIES (Pennsylvania Salt Mfg. Co.). U. S. 2,159,843, May 23, 1939 (Aug. 18, 1937).—A process of preparing a solid sodium aluminate product comprises separately supplying heat to caustic soda containing about 95% to 100% NaOH to provide a temperature thereof above its melting point and admixing therewith a solid subdivided alumina hydrate, the reactants being present in such molecular proportions that the Na_2O content is greater than the Al_2O_3 content and the temperature of the caustic soda being above its liquefying point but below 600°C to cause a reaction between the reactants and to free the mixture of at least a portion of the water to form a plastic mass, without the application of further heat, during the reaction stirring the mixture, and converting the reaction mass into a solid state.

Manufacture of alkali metasilicates and alkali metasilicate-containing compositions. MAX JAEGER AND FRANZ BESEMANN (I. G. Farbenind. A.-G.). U. S. 2,161,515, June 6, 1939 (Jan. 13, 1933).—A process comprises heating quartz sand with a quantity of caustic potassium lye of commercial concentration, in an excess of several per cent of that theoretically required for the formation of the metasilicate, to boiling temperatures, while agitating the reaction mass, until a temperature of about 190°C is attained and then maintaining a temperature between about 190°C and 200°C until crystallization of the mass is completed.

Preventing the caking of sodium perborate. J. S. REICHERT AND H. L. POTTER (E. I. du Pont de Nemours & Co., Inc.). U. S. 2,159,999, May 30, 1939 (Sept. 29, 1937).—A dry stable mixture comprises sodium perborate in powdered form and sufficient magnesium benzoate to stabilize the powdered sodium perborate against caking upon storage.

Production of alkali aluminates. T. R. HAGLUND. Swiss 201,283, May 19, 1937; *Chem.-Ztg.*, **63** [14] 134 (1939). D.A.B.

Production of calcium silicate. N. P. PITT AND E. G. BAKER. Fr. 837,696, May 7, 1938; *Chem.-Ztg.*, **63** [27] 241 (1939). D.A.B.

Titanium dioxide pigments. K. W. PETERSEN (I. G. Farbenind. A.-G.). U. S. 2,161,975, June 13, 1939 (Jan. 8, 1937).—In the process for the improvement of titanium dioxide for use as a pigment, a step comprises stirring titanium dioxide with a solution of a basic aluminum salt.

General

Air conditioning in industry: III. W. L. FLEISHER, A. E. STACEY, F. C. HOUGHTEN, AND M. D. FERDERBER. *Heating, Piping & Air Conditioning*, **11** [4] 255–68 (1939). Test data and results on the physiological reactions of individual workers to high effective temperatures are presented and discussed. Codes and laws governing temperature working conditions are considered. Problems of the engineer in selecting air-handling equipment to produce atmospheric conditions below critical temperatures to be established for different industries are explained. 20 figures. 73 references. For Part II see *Ceram. Abs.*, **18** [7] 189 (1939). J.L.G.

American Ceramic Society exhibits at Exposition. ANON. *Bull. Amer. Ceram. Soc.*, **18** [6] 220 (1939).

Borehole at the Zenith mine, Ely, Minn. J. B. NEWSOM AND W. D. HASELTON. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1068; *Mining Tech.*, **3** [3] 14 pp. (1939).—This borehole, $5^1/_2$ ft. in diameter and 1208 ft. deep, was drilled for ventilation. The hole was finished in less than seven months. The average advance per day was 5.8 ft.; the advance for the best week was 77 ft. Cost for labor and supervision was $12.16/ft. and that for power and materials was $7.34/ft.; the total cost was $19.50 Accident hazards and prevention are discussed. W.D.F.

Composition of stone and inhaled dust in relation to silicosis: I–II. A. SHAW. *Colliery Guardian*, **158**, 522–24; 572–75 (1939).—There is a definite silicosis risk in the Somerset and North Staffs coal fields among the workers in highly siliceous rock, but in the South Wales anthracite area, most of the certified cases are mainly miners working at the coal face, with very little quartz dust present. This latter disease is probably bronchitis. On analysis, five micron dusts usually have less free silica than the parent rock. Silicosis may be caused by work in a highly siliceous rock, but the converse is not always true. Dust from drilling is more siliceous than that from crushing; for two rocks, the free silica content is 58 and 60%; in dust from drilling, 42 and 49%; and in dust from crushing, 33 and 30%. See "Silicosis—," *Ceram. Abs.*, **18** [7] 197 (1939). W.D.F.

Duty and aim of the German Ceramic Society. R. Rieke. *Ber. Deut. Keram. Ges.*, **20** [2] 88–92 (1939). C.H.R.

Elimination of dust in a porcelain plant. A. M. Morris. *Ceram. Ind.*, **32** [6] 36–37 (1939).—The problem of preventing silicosis is one of preventing dust from reaching the breathing zone of the operator. At the insulator plant of the Ohio Brass Co., dust conditions were analyzed, each hazardous location was studied in detail, and the best means for eliminating dust were installed. Tests showed that exhaust ventilation was the only real solution to the problem; experiments with water proved unsatisfactory. Illustrated. L.M.C.

Exploring drill holes by sample-taking bullets. Eugene G. Lenardon and D. C. McCann. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1062; *Petroleum Tech.*, **2** [2] 13 pp. (1939).—A side wall sample taker has bullets consisting of hollow cylinders, which are fired by powder into the side of the drill hole. The bullet is attached by two wires to the housing so that it can be recovered. Six to 18 bullets are used, and they are fired individually where cores are wanted. These bullet cores are 0.75 in. in diameter and 1.5 to 2.5 in. long. They are not compacted or crushed. The recovery of cores is about 70% efficient. W.D.F.

Functions of a Dominion Department of Mines. R. C. Rowe. *Trans. Can. Inst. Mining & Met.*, **42**, 59–67 (1939).—R. gives a history of the Canadian Department and compares its functions with those of the United States Geological Survey and the Bureau of Mines. He gives suggestions for extension of services. G.M.H.

General theory of heating by radiating surfaces. K. Kalous. *Chaleur & Ind.*, **19** [224] 619–31 (1938).—The heating of rooms by radiating walls or ceilings is discussed in a highly mathematical treatment of the principles of calculating heating by radiation and a comparison of radiation and convection. The calculation of transfer of heat must be conducted in the same manner as in the case of convection. To calculate the dimensions for heating surfaces, the coefficient of transmission of heat must be used in place of the coefficient of heat flow. The network of pipe radiators must be determined in the same way as for convection systems. V.D.F.

Industrial view of engineering education. O. W. Eshbach. *Elec. Eng.*, **58** [1] 19–22 (1939).—Industry needs both the highly professional education that is prerequisite to the expectancy of further future development of new products and methods and the more diversified preparation that is vital to operation and management. The united efforts of all engaged in engineering education are necessary if the best program is to be achieved. P.G.H.

New Industrial Minerals Laboratories. Anon. *Can. Mining & Met. Bull.*, No. 324, pp. 110–12 (1939).—The new laboratory and office building of the Industrial Minerals Division, Department of Mines and Resources, Ottawa, is now in use. G.M.H.

Pigmentation of lungs and the origin of their iron pigment. I. M. Peisakhovich. *Rec. trav. XXXV annivers. activité méd., sci. pédagog. sociale I. I. Faĭnschmidt*, **1937**, pp. 116–23 (in Russian); *Chem. Abs.*, **33**, 3019 (1939).—In experimental pneumoconiosis in dogs, the Fe pigment originates from the decomposition of erythrocytes due to a blocking of the lymphatic system and subsequent disturbance of the circulation. Hemosiderin originates endogenically, as a result of exogenous penetration of coal and silicate dusts into the lungs.

Practical methods for the control of hygienic exposures. G. A. Coburn. *Amer. Jour. Pub. Health*, **29** [5] 501 (1939).—Depending upon their effect upon the body, dusts may be classified into two types: (1) those capable of producing respiratory ailments and (2) those causing systematic poisoning, *e.g.*, lead compounds, etc. Studies pertaining to the control of dust and fumes in specific cases are described. Air velocities of 4000 cu.ft./min. for most dusts and 2500 to 3000 cu. ft./min. for gas fumes and smoke are recommended. **Discussion.** Charles L. Poole.—P. describes the control of dust in an enamel plant and the recovery of pottery glazes with a reduction in dust. Means of planning an exhaust system, emphasising particularly proper dust construction, are described. B.C.R.

Prevention of silicosis by metallic aluminum. J. J. Denny, W. D. Robson, and Dudley A. Irwin. *Trans. Can. Inst. Mining & Met.*, **42**, 238–56 (1939); *Can. Med. Assn. Jour.*, **40**, 213–38 (1939).—Experimental work shows that in lungs containing 1% or more metallic aluminum, silicosis is prevented or inhibited under the same conditions in which lungs containing no aluminum developed silicosis within a few months. Persons exposed to these conditions should inhale aluminum dust daily. Aluminum dust so used should be below 5 microns in size, should be grease-free, and should be uniformly mixed in any inhaled silicosis-producing dust in definite proportion to it. It should be sufficiently concentrated to produce a minimum concentration of 1% in the lung at all times. Aluminum dust inhaled in large quantities over long periods has shown no effect on general health of animals and no evidence of toxicity or damage to tissues. In any necessary concentration it is extremely below the explosive concentration of aluminum powder. See "Aluminum—," *Ceram. Abs.*, **17** [1] 46 (1938). G.M.H.

Professional phase of engineering education. Parker H. Daggett. *Elec. Eng.*, **58** [1] 16–18 (1939).—In the opinion of D., the distinguishing feature of a professional course is, or should be, that it is built on the basic engineering sciences which must precede it, and the emphasis in the course should be on a most thorough analysis of these principles as applied to fundamental practical problems. P.G.H.

Report of Committee on Patents. F. B. Flick, Chairman. *Bull. Amer. Ceram. Soc.*, **18** [6] 211–12 (1939); see *ibid.*, **16** [10] 392–400 (1937).

Research laboratory of the National Lead Co., Titanium Division. Walter W. Plechner and Sandford S. Cole. *Ind. Eng. Chem., Anal. Ed.*, **11** [5] 299–302 (1939).—The research facilities of this laboratory are described in detail. Illustrated. F.G.H.

Sudeten-German ceramic industry. F. Zapp. *Ber. Deut. Keram. Ges.*, **20** [2] 99–102 (1939).—A résumé of the ceramic industry in this area is presented. The most important phase is the porcelain industry which is concentrated about Karlsbad. Stoneware, sanitary ware, tile, and sintered ware are produced. C.H.R.

Use of combustible liquids in heating and tests on a compressed air burner. M. Steffes. *Chaleur & Ind.*, **19** [224] 647–50 (1938).—S. outlines the considerations to be followed in choosing combustible liquids and burners for use in heating plants. Steam injector burners and mechanical burners using a mechanical mixture of fuel and air are discussed. The results of tests on a commercial burner are given. V.D.F.

Francis William Walker. Anon. *Bull. Amer. Ceram. Soc.*, **18** [6] 227–29 (1939).

Wet drilling conditions specified for New York State. H. C. Chellson. *Eng. Mining Jour.*, **140** [4] 29–31 (1939).—The manufacturers of drills and specifications which meet the code set to combat silicosis are listed as approved by the State Board of Standards and Appeals. Standards for general ventilation in confined areas using drifter-mounted and wagon-mounted drills are listed together with a tabulation of mechanical ventilation requirements for wet drilling. See "Combating—," *Ceram. Abs.*, **17** [8] 293 (1938). J.L.G.

BOOKS AND SEPARATE PUBLICATIONS

Industrial Medicine. W. Irving Clark and Philip Drinker. National Medical Book Company, Inc., New York. 262 pp. Price $3.00. Reviewed in *Foundry*, **64** [4] 106 (1936).—Valuable information for the management of industrial concerns operating or inaugurating medical departments is provided. F.G.H.

Ore-dressing studies: Metallurgical Division Progress Report No. 31, Flotation of southern Illinois lead-zinc-fluorspar ores. J. B. Clemmer, W. E. Duncan, F. D. DeVaney, and M. Guggenheim. *U. S. Bur. Mines Repts. Investigations*, No. 3437, 31 pp. Free. Observations and data obtained in applying selective flotation to

several ores from the Cave-in-Rock area for the production of lead, zinc, and fluorspar concentrates are recorded.

R.A.H.

Publications of the Kaiser-Wilhelm Institute for Silicate Research in Berlin-Dahlem: Vol. 9 (Veröffentlichungen aus dem Kaiser-Wilhelm Institut für Silikatforschung in Berlin-Dahlem). Edited by W. EITEL. F. Vieweg & Sohn, Braunschweig, 1938. 163 pp. Price 9 Rm. Reviewed in *Ber. Deut. Keram. Ges.*, **20** [4] 213 (1939).

C.H.R.

PATENTS

Ceramic materials. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 505,165, May 17, 1939 (Dec. 30, 1937). Brit. 505,830, June 1, 1939 (Dec. 30, 1937).

Ceramic-to-metal seal. HANS PULFRICH (General Electric Co.). U. S. 2,163,407, June 20, 1939 (Oct. 1, 1937).—In combination, a metal member, a ceramic body comprising by weight about 30 magnesia, 61 silica, 4 alumina, 2 lime, and 3% pyrolusite, a thin layer consisting of refractory metal powder on the surface of the ceramic body and adhesively held to the body by a eutectic solid solution of the body, and a solder with a melting point below the softening temperature of the solution joining the metal member and the metal powder on the ceramic body.

Ceramic-to-metal seal. HANS PULFRICH (General Electric Co.). U. S. 2,163,409, June 20, 1939 (Nov. 22, 1937). HANS PULFRICH AND RICHARD MAGNER (General Electric Co.). U. S. 2,163,410, June 20, 1939 (Nov. 22, 1937).

Production of ceramic objects. A. P. DE SANDO, JR. Fr. 839,543, June 20, 1938; *Chem.-Ztg.*, **63** [28] 250 (1939).

D.A.B.

THE AMERICAN CERAMIC SOCIETY TRUSTEES AND OFFICERS FOR 1939–1940

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White Wares: E. H. Fritz, Westinghouse Electric & Mfg. Co., Derry, Pa. (1941)
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